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AUTHOR Svinicki, Marilla Scott; Symannek, Brigitte
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ABSTRACT

The first of these two articles presents the methods, results, and discussions of six experiments which employed an avoidance of time-out from positive reinforcement schedule with human subjects to investigate: (1) whether time-outs may be considered aversive events; and (2) if so, whether the aversiveness was sufficient to produce aggressive behavior. Results showed that time-out from positive reinforcement functions as a negative reinforcer for human avoidance behavior, and also elicits aggressive behavior under certain conditions within the avoidance paradigm. Extensive research is cited both in the introduction and the general discussion. The second paper describes a similar study which sought to explore methods for the automatic measurement of aggression in humans in a situation where independent and dependent (aggressive behavior) variables were specified. Fourteen college freshmen served as subjects to determine whether the blocking of reinforcement by a rat elicited aggressive behavior toward the rat. All responses were in the form of pushing buttons. Results showed that many subjects responded to the blocking of reinforcement by the rat by inflicting pain on it. (TL)

ED 044718

Avoidance of Time-Out From, and Withdrawal of, Positive Reinforcement in Humans: Reduction in Actual and Potential Reinforcement as a Stimulus for Aggression[1]

Brigitte Symannek[2]

Western Michigan University

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TABLE OF CONTENTS

CHAPTER		PAGE
I	INTRODUCTION	1
II	EXPERIMENT I: Acquisition of Avoidance of Time-out From Positive Reinforcement. .	6
	Method	6
	Results and Discussion	11
III	EXPERIMENT II: Effects of Various Fixed-ratio Avoidance Criteria	15
	Method	15
	Results and Discussion	17
IV	EXPERIMENT III: Shock Delivery and Shock Opportunity	22
	Method	22
	Results and Discussion	24
V	EXPERIMENT IV: Magnitude of Negative Reinforcement	28
	Experiment IVa: Avoidance of Actual and Potential Loss of Positive Reinforcement .	29
	Method	29
	Results and Discussion	30
	Experiment IVb: Avoidance of Withdrawal of Positive Reinforcement	32
	Method	32
	Results and Discussion	34
VI	EXPERIMENT V: Extinction of Positive and Negative Reinforcement	37
	Method	38

TABLE OF CONTENTS, continued

CHAPTER		PAGE
	Results and Discussion	40
VII	GENERAL DISCUSSION	46

INTRODUCTION

Experimental analyses of aggressive behavior in animals have shown that it occurs with great reliability in response to aversive stimulation (Ulrich and Azrin, 1962). The majority of studies have concentrated on painful stimulation (O'Kelly and Steckle, 1939; Ulrich, Hutchinson and Azrin, 1965; Scott and Fredericson, 1951; Ulrich and Symannek, 1968; Vernon and Ulrich, 1966; Azrin, Hutchinson and Hake, 1963). Shock has been studied most extensively because of its relatively high degree of parametric controllability (Ulrich and Azrin, 1962; Azrin, Ulrich, Hutchinson and Norman, 1964; Hutchinson, Azrin and Renfrew, 1968). The type of aggressive behavior most typically studied is the stereotyped fighting in paired rats (Ulrich and Azrin, 1962) and the biting attack of a monkey toward a pneumatic hose as response sensor (Hutchinson, Azrin and Hake, 1966).

The specific functional relationship between aversive stimulation and aggressive behavior has been shown to be a factor that interfered with the acquisition and maintenance of aversively controlled operant behavior. Azrin, Hutchinson and Hake (1967) reported that acquisition of a shock escape response in a rat was noticeably retarded by a high tendency to attack when another restrained rat was present in the experimental chamber. Attack probability, however, progressively decreased during conditioning of the escape behavior. In contrast to these results, Ulrich and Craine

(1964) and Ulrich (1967) found that previously learned, solitary avoidance escape or cooperative escape behavior in rats was disrupted when a second unrestrained rat was introduced into the situation, or when two subjects conditioned solitarily were paired.

Similar results were obtained concerning the superiority of single subjects over paired subjects in the acquisition of Sidman avoidance in rats (Ulrich, Stachnik, Brierton and Mabry, 1965). The authors contend that the observed aggressive behavior occurred as a function of painful stimulation by the received electric shocks. This explanation applies logically to the case of an escape schedule where effective behavior presupposed the reception of shock and a clear dominance of escape and aggressive responses can be established. In the case of a continuous avoidance schedule, however, escape and attack are not mutually exclusive, because characteristic elements of the schedule provide for a different temporal spacing between the two behaviors. Avoidance responding has to occur prior to the prospective shock, whereas elicited aggressive behavior can occur after an unavoided electric shock has been received. Thus, it appears that the only way in which shock-elicited aggressive behavior would interfere with avoidance behavior is through strong skeletal and visceral responses that conflict with the maintenance of the conditioned interresponse times for avoidance (Anger, 1963).

A determination of the temporal relation between shocks and aggressive responses in an avoidance situation should clarify whether the occurrence of aggressive responses is a direct result of received shocks. Azrin, Hutchinson and Hake (1967) reported

that, under a continuous avoidance schedule, monkeys would not bite a rubber hose unless they received unavoided shocks. Their data demonstrated that very few shocks were delivered because of a steady rate of avoidance responding. These results could be due to the fact that biting a hose and pressing a bar were not compatible because: (1) by the nature of both responses, they could hardly be emitted simultaneously, and (2) biting was more likely than was the avoidance response to be followed by shock as an aversive event.

An alternative explanation for the occurrence of aggression in social avoidance situations is suggested by several studies dealing with potential aversiveness of avoidance schedules. Sidman (1962), Verhave (1962), Findley and Ames (1965) and Findley, Schuster and Zimmerman (1966) have shown that time-out from, or termination of, an avoidance schedule will function as a reinforcer for behavior in both continuous and discriminated avoidance schedules. In view of these findings, aggressive behavior under avoidance contingencies might well be evoked by aversive components of the avoidance schedule, rather than exclusively controlled by received shocks. It had been shown before that schedules of reinforcement of an operant response which are characterized by a high degree of response strain, intermittent positive reinforcement schedules, for example, will induce biting attack in a monkey and pecking attack in a pigeon (Hutchinson, Azrin and Hunt, 1968; Gentry, 1968). Although Hake (1968) demonstrated that aversive properties of an avoidance schedule are determined by the frequency of actual shock as opposed to potential shock, and thus appears to render the above differen-

tiation between schedule- and shock-specific aversive effects an artificial one, it still has to be established whether the above factors are synonymous or functionally separable in the case of aggressive behavior.

It appears that this can be answered only in an avoidance situation in which both the aggressive and the avoidance responses are possible simultaneously without interfering with each other. The use of a discriminated instead of a continuous avoidance schedule should facilitate identification of the specific temporal positions of the avoidance response. Rather than using electric shock as negative reinforcer, a stimulus should be employed that does not have an equally high probability of interfering with the physical execution of the avoidance response. The stimulus chosen must be strong enough to elicit aggression by itself to be comparable to the eliciting power of electric shock. Azrin, Hutchinson and Hake (1966) found that noncontingent extinction after a period of positive reinforcement would induce pecking attack in a subject pigeon toward a target pigeon. These findings confirm the hypothesis that the removal or withholding of positive reinforcement, after a history of reinforcement, is aversive (Brown and Farber, 1951: Lawson and Marx, 1958; Amsel, 1958, 1962). The extent of aversiveness is indicated by two behavioral controls: (1) avoidance behavior can be conditioned on the basis of time-out from positive reinforcement and increased in rate by decrements in the R-S interval (Ferster, 1958: Morse and Herrnstein, 1956); and (2) withholding of a previously obtained reinforcer will elicit emotional aggressive behavior. This

has been shown in the case of withdrawal of morphine from previously addicted rats (Boshka, Weisman and Thor, 1966), sleep deprivation in human adults (Sears, Hovland and Miller, 1940), withdrawal of food from a nursing infant (Sears and Sears, 1940) and interference with the completion of an operant task (Ulrich and Favell, 1968).

The present series of studies employed an avoidance of time-out from positive reinforcement schedule with human subjects to investigate whether: (1) there are any aversive properties connected to the contingencies of the avoidance schedule, (2) there are any aversive effects that are primarily controlled by the to-be-avoided aversive stimulus (time-out), and (3) there are any effects correlated to the variables that are aversive enough to produce aggressive behavior. Aggressive behavior was operationally defined as the response of pressing a switch which delivered electric shock to a rat. Hence, any functional statements about variables that control aggressive behavior in this situation are made within the framework of this definition.

EXPERIMENT I

An Analysis of the Acquisition of Avoidance of Time-out from Positive Reinforcement in Humans

The present experiment investigates the acquisition of responding under a conjugate reinforcement schedule consisting of the components chain [VI positive reinforcement / concurrent (VI reinforcement/FR avoidance)]. Each of the two schedules were associated with one response manipulandum, A third manipulandum, not a functioning part of the conjugate schedule, was available at all times to deliver shock to the target rat. No instructions were given in relation to the positive reinforcement schedule other than that the subject was to press buttons. Avoidance behavior in some subjects was established by providing them with explicit instructions concerning avoidance contingencies.

METHOD

Subjects

Five male undergraduate college students volunteered to serve as subjects. None were psychology majors. Their prior exposure to operant conditioning methodology was restricted to elementary laboratory experiments conducted within the framework of an introductory psychology class.

Apparatus

The response console, shown in Figure 1, measured approxi-

mately 2 x 2 x 7 feet. Its front consisted of several interchangeable

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Insert Figure 1 about here

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panels. The intelligence panel contained three toggle switches with vertically aligned 1-inch handles as manipulanda. They were separated by approximately 3 inches and operable only in a downward direction. Complete depression of the handle closed a microswitch that recorded a response and provided audible feedback. In addition, each press on switch (B) produced a 0.2-second flash of a red light (b_2). Two lights (a and b_1) located to the left of switches (A) and (B) were later functional as discriminative stimuli. Presses of switch (C) delivered electric shock to a rat.

A plexiglas panel in the response console above the intelligence panel provided complete visual access to the illuminated rat chamber (12 x 12 x 10 inches). The chamber floor was constructed of stainless steel rods 0.25-inch in diameter, through which electric shocks of 0.3-second duration could be delivered. Shock intensity was 2.5 ma as calculated on the basis of open-circuit source voltages and a 47K limiting resistor under conditions of shorted output. The shock source was a Grason Stadler shock generator (No E6070B) which provided for alternation in polarity of adjacent grid bars.

Hooded Long Evans male rats were used in the shock chamber as target objects. They were approximately 100 days of age at the start of the experiment and had no shock history. New target animals were sometimes substituted when health conditions or changes

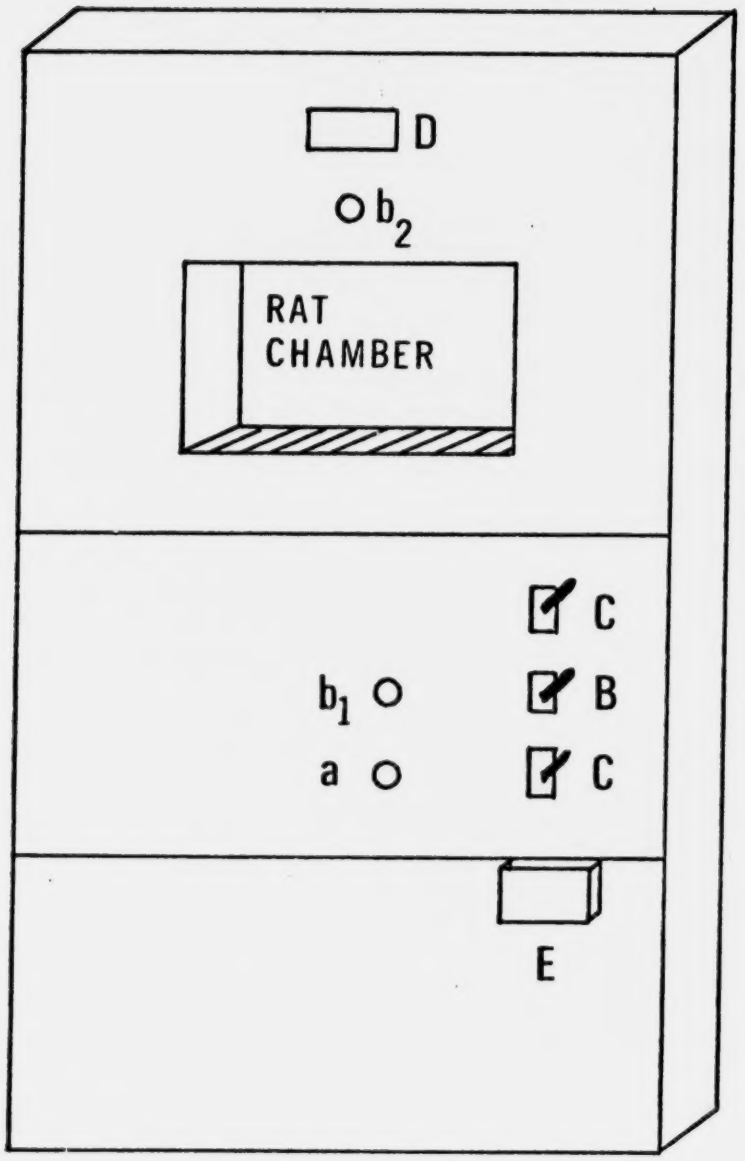

Figure 1.

Response console, measuring 2 X 2 X 7 feet. A = reinforcement switch; B = avoidance switch; C = shock switch; D = counter; E = reinforcer container; a = discriminative stimulus for reinforcement period; b_1 = warning stimulus for avoidance; b_2 = red stimulus light. During Experiments I, II, III, and V, counter (D) was not present. During Experiment IV, switch (A) and light (a) were completely covered by a metal plate and the reinforcement container was absent.

in skin resistance made a replacement necessary.

A Davis Universal Feeder (No 310) inside the console was used to deliver reinforcement into a metal container (E).

The response console was situated in a sound attenuated room of approximately 6-1/2 x 4-1/2 x 8 feet. Ventilation, white masking noise and vacant areas immediately surrounding each end of the room helped to buffer extraneous noise. In addition to the response console, the experimental room was furnished with a chair, carpeting and overhead lighting. The subjects were monitored by a closed-circuit TV camera hidden behind a ventilation shutter in the upper right wall. Relay control equipment was situated approximately 10 feet from the experimental area.

Procedure

All subjects were initially tested for their basic rate of responding under the unique stimulus conditions associated with switches (A), (B) and (C). Response on switch (A) did not result in any stimulus change; response on switch (B) produced a 0.2-second flash of light (b_2); and each press of switch (C) delivered a 0.3-second shock to the rat.

During Phase II, light (a) was presented at the onset of a session. After 2 minutes 50 seconds, light (b_1) came on for a maximum duration of 10 seconds. If five responses on switch (B) occurred during this time, light (b_1) would terminate after the fifth response; light (a) would remain on for another 2 minutes 50 seconds, at which time light (b_1) would be presented again. If the response criterion

was not met, both lights (b_1 and a) would terminate simultaneously after 10 seconds. In this case, 3 minutes would pass before light (a) would be presented again to reinstate the same procedure. At all times, response on switch (B) would activate the flashing red light (b_2) and response on switch (C) would deliver shock to the rat.

The rationale for Phase II was to test for the effects which lights (a) and (b_1) would have on responding on switch (A) and (B). Specifically, it was analysed: firstly, whether light (b_1), which subsequently was to serve as a warning stimulus within the avoidance schedule, would by itself exert some systematic control over responding on switch (B) and secondly, whether the presence of light (a) would reinforce responding on switch (B).

In Phase III, the subjects were exposed to the terminal chain [VI reinforcement / concurrent (VI reinforcement/FR avoidance)] schedule. In the presence of light (a), responses on switch (A) were reinforced according to a 1-minute variable schedule with an added limited hold 3-second contingency. Reinforcement consisted of 1 nickel. The FR-avoidance component of the schedule was set into effect at the onset of light (b_1), which later was intensified by the click of an additional feedback relay. Completion of a predetermined fixed number of responses on switch (B) in the presence of the CS (light b_1) constituted the criterion for avoidance of the 3-minute time-out. The avoidance criterion was 1 response for S 501 and S 504, and was subsequently raised to 5 responses, which was the fixed ratio at which S 505 and S 507 were conditioned. During TO, no reinforcement for responses on switch (A) was available. Fol-

lowing TO, a new reinforcement interval was instituted, whereas in the case of avoidance, it would begin as soon as the ratio was completed. Responses on switch (C) would deliver shock to the rat at all times.

Sessions 30 minutes in length were conducted 5 days a week. The initiation and completion of a session was indicated by onset and offset of the house light in the rat chamber.

Before the beginning of the experiment, all subjects were informed that they could receive a maximum of $1.75 per session. $1.50 could be obtained for each single session and an additional 25¢ per session would be paid at the end of the week if the subject had attended all sessions as scheduled. The following information was read to each subject just prior to the start of the first session:

> "You will have to work on your own in this room for 30 minutes each day. Your task is to press these switches. This is all I can tell you now. If there is any major change in the conditions under which you will work here, you will be informed about it. Please, do not leave this room during the half hour."

Before introduction of the VI-reinforcement schedule, subjects were paid a fixed amount of $1.50 at the end of each session. When the VI-contingency was initiated, they were informed that now their pay would be a combination of the amount they could earn during the session plus the $1.25 per week contingent upon reliable attendance. No further information was given to subjects 501, 506 and 507. On the fourth and fifth sessions of avoidance

training, subjects 504 and 505 received the following additional information:

> "You might have noticed already that you can get money only by pressing this bottom switch, and that you get it only when this light is on." (The experimenter pointed to switch (A) and light (a).) "You can keep the light on the whole session. To do that, you have to press the second switch when the light near it is on." (The experimenter pointed to switch (B) and light (b_1).) "Again, as soon as this second light comes on, you have to press the second switch if you want the bottom light to stay on."

In all cases, instructions were read to the subject. They were repeated if questions were asked at that time or if the subject's behavior during subsequent sessions indicated an obvious misunderstanding of the contingencies.

RESULTS AND DISCUSSION

During Baseline I, distinct differences between rates of responding on the three switches were observed for all subjects but S 504. Figure 2 depicts the number of responses on each manipulandum per session. S 504 maintained response rates of as low

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Insert Figure 2 about here

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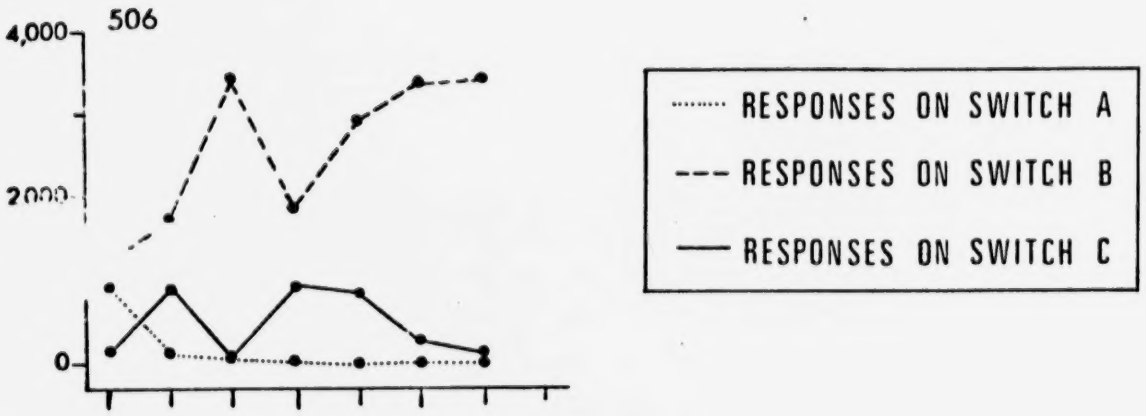
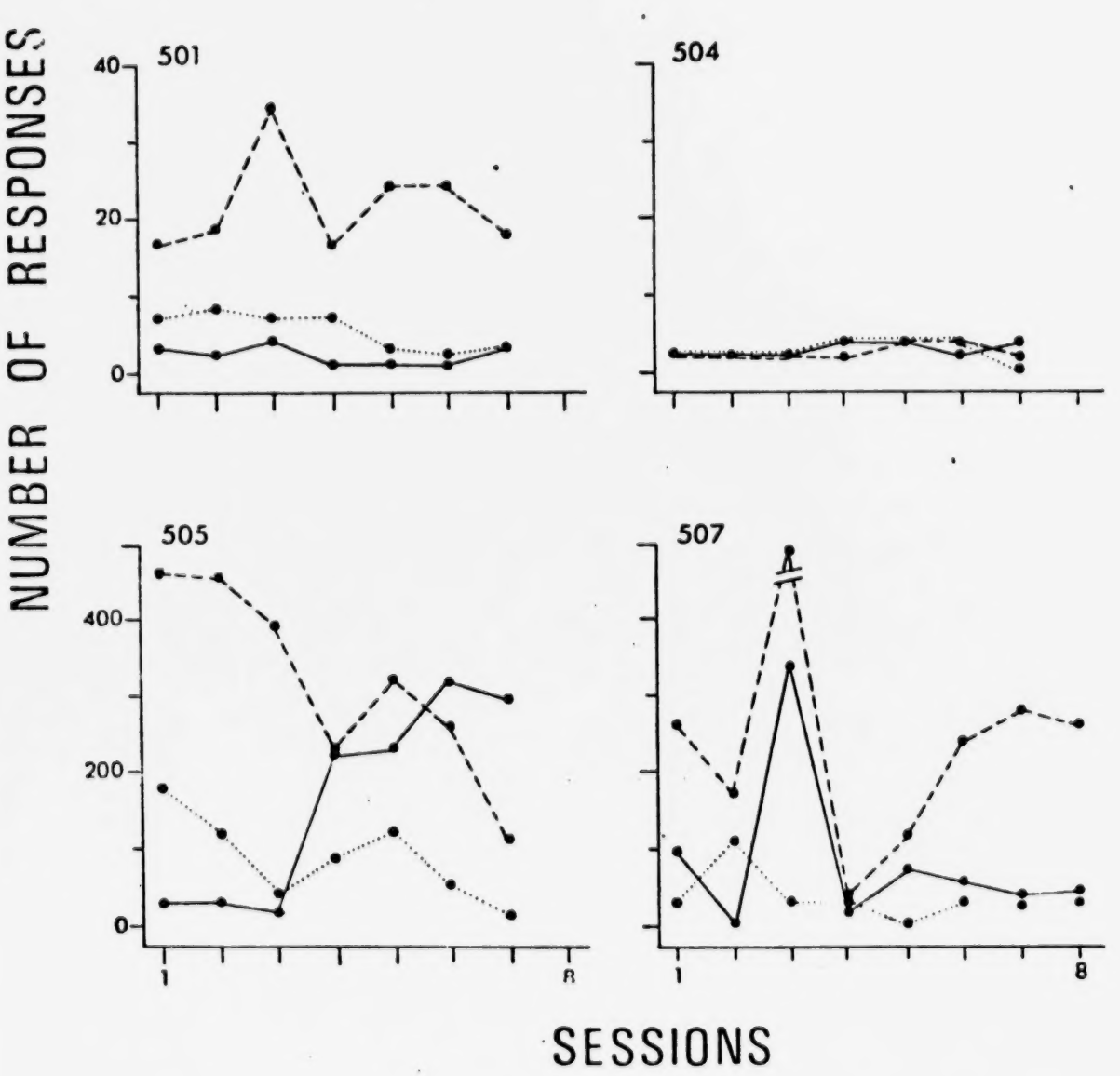
as 1-3 responses per session consistently on all switches. Three other subjects (S 505, S 506 and S 507) displayed a preference for switches (B) and (C) both of which, in contrast to switch (A), provided unique visual and some auditory feedback in addition to the general feedback given by manipulation of any of the switches. Initially, response rates on switch (B) which produced a short flash

Figure 2

Frequency of responding on switch (A), (B) and (C) during Baseline I. Responses on switch (A) did not produce any programmed feedback; responses on switch (B) produced a flash of the red feedback light (b_2); responses on switch (C) delivered electric shock to the rat.





of a red light (b_2) exceeded the rates on switch (C) which delivered electric shock to the rat. This pattern of responding was maintained throughout the total phase by subjects S 501, S 506 and S 507, while S 505's shock response rate progressively increased to a level beyond his rates for switches (A) and (B). For all subjects, responding on switch (A) was characterized by a progressive decrement across sessions.

Introduction of lights (a) and (b_1) in Baseline II did not appear to exert any control over responding on switch (B) except in the case of S 506. The data presented for Baseline II in Figure 3 demonstrate that none of the other four subjects consistently emitted the five required responses on switch (B) in the presence of light (b_1) in order to keep light (a) present. These results indicated

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Insert Figure 3 about here

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the absence of any reinforcement power of light (a) in this context. The apparent high probability of meeting the 5-response criterion that was displayed by S 506 seemed to be a coincidental side effect of his high basic rate of about 73,71 responses per minute on switch (B) during light (b_1). This analysis is even more plausible considering the fact that his response rates on switch (B) were higher during the intertrial interval when both lights (b_1) and (a) were off (268.73 responses/minute), or when only light (a) was present (93.806 responses/minute).

The results of Phase II clearly established that light (b_1) prior to being functional as warning stimulus for avoidance did not

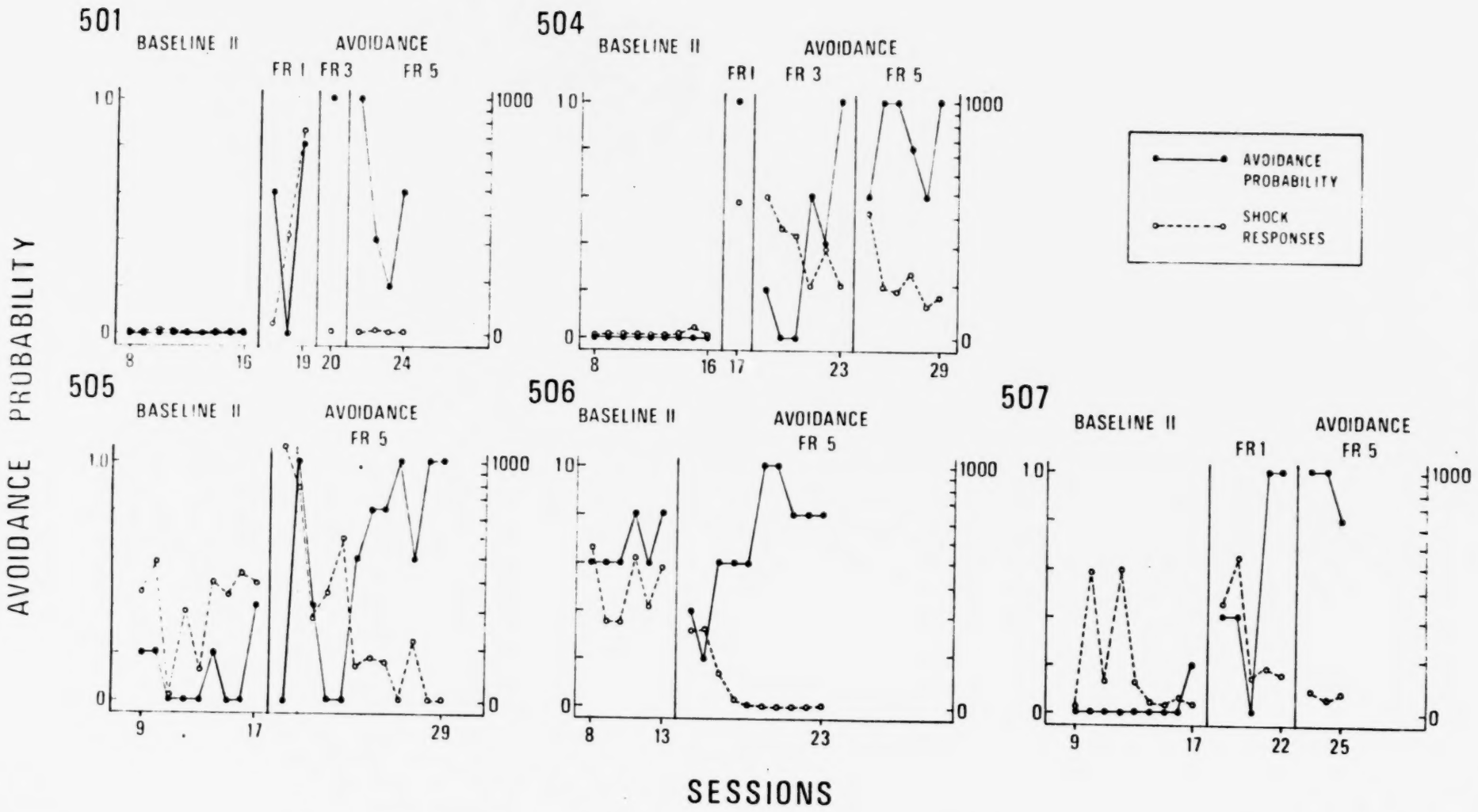

Figure 3

Avoidance probability and shock responding during Baseline II and acquisition of avoidance responding. The data points for Baseline II represent mean probabilities of meeting the 5-response requirement on switch (B) during the presence of the warning stimulus. Data points under acquisition of avoidance depict avoidance probabilities under the specified fixed-ratio avoidance criteria. During sessions designated by (I), instructions about the avoidance contingency were given to the subject. Data include 3 sessions following acquisition.

exert control over responses emitted on switch (B).

In addition to responding during Baseline II, Figure 3 shows the gradual development of avoidance behavior upon introduction of the contingency of avoidance of time-out from positive reinforcement for responses on switch (A). Acquisition of avoidance was defined as a maximum total of 3 minutes of time-out during two consecutive sessions. S 501, S 505 and S 506, who had received no instructions about the avoidance schedule, had reached the criterion for avoidance within 5-9 sessions. The response pattern of S 504 and S 507 indicated the development of an association of all three switches with the avoidance of time-out and the delivery of positive reinforcement. S 505 was alternating sequentially between manipulation of the three switches. To prevent a superstitious correlation between the shock switch and positive or negative reinforcement, detailed instructions about the avoidance contingencies were given to S 504 on session 21 and to S 507 on session 20. Within 3 to 5 sessions, both subjects met the criterion for acquisition.

In addition to avoidance probabilities, Figure 3 also presents the number of shock responses per session during Baseline II and acquisition of avoidance. While the level of shock responding was near zero for subjects 504 and 501 during Phase II, subjects 505, 506 and 507 initially maintained a rate that ranged up to a maximum of about 400 responses per session. Introduction of the avoidance contingency produced an increase in shock responding for all subjects except S 506. During conditioning of avoidance behavior, however, rate of shock responding showed a progressive decrement which finally

stabilized on a near-zero level for subjects 501, 505 and 506. An average of 35 to 70 shock responses per session was maintained by S 507 and S 504 respectively. This rate appeared to be stable throughout the course of this and the following experiments.

During acquisition of avoidance behavior, the higher rates of shock responses seemed to be correlated with low avoidance probability, suggesting a functional relation between the two factors. A further analysis, concentrating on sessions after the establishment of avoidance behavior, shows that this hypothesis was not confirmed as a general phenomenon. Figure 4 presents, for all sub-

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Insert Figure 4 about here

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jects, shock response frequency as a function of avoidance probability under an FR-5 avoidance requirement. The presented data are based only on sessions after the conditions for avoidance acquisition had been met. It can be seen that for three subjects (S 501, S 505 and S 506) the number of shock responses is inversely related to avoidance probability. For S 504, shock responses decreased in frequency with enhanced avoidance performance. No relation between the two variables could be established for S 507.

Since the obtained function between avoidance performance and shock responding was not monotonic and could not be observed across all subjects, further investigation was needed before any conclusion could be drawn about an eventual interrelation between elements of the avoidance schedule and the behavior of shocking a rat.

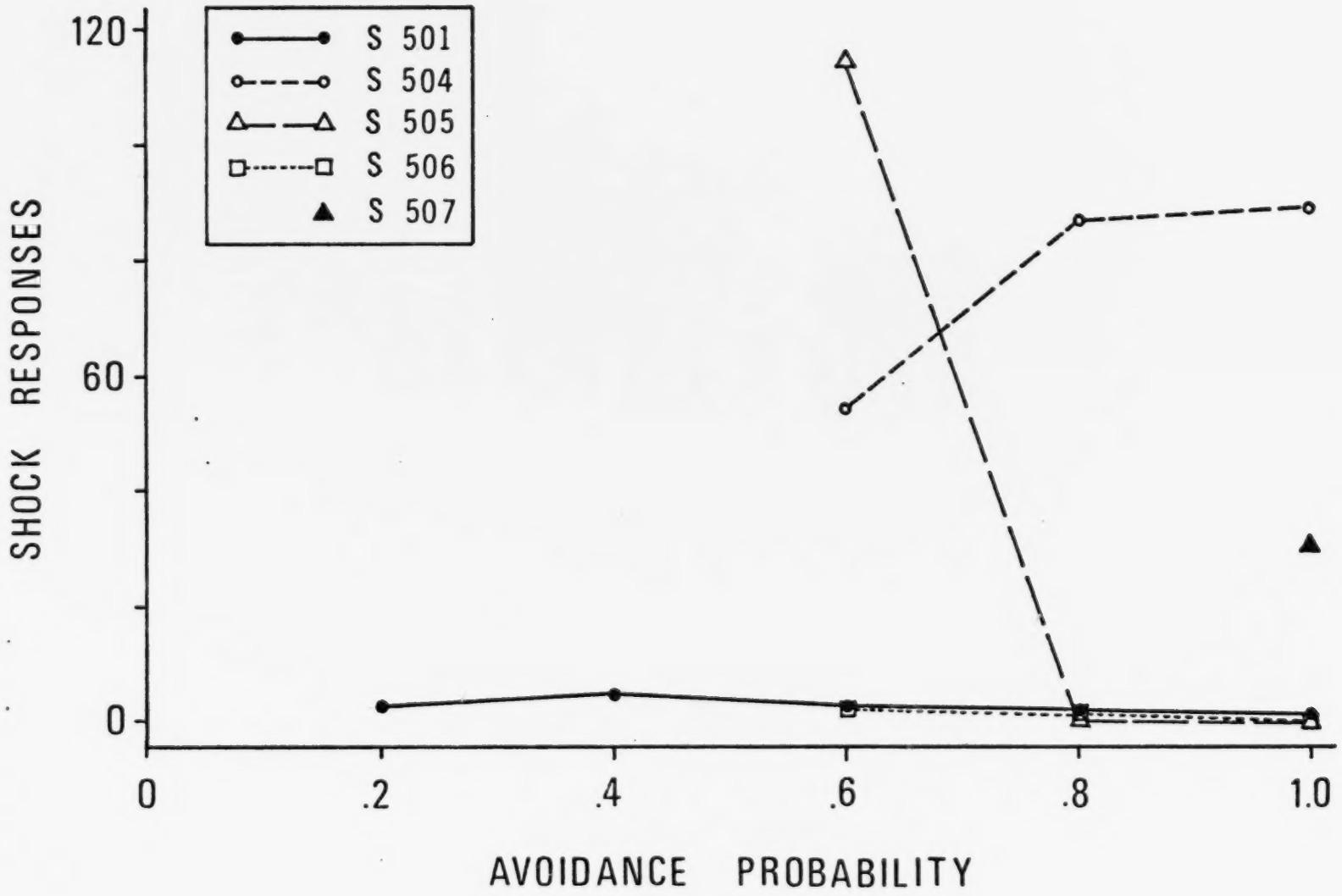

Figure 4

Mean shock responses as a function of avoidance probability for all subjects under FR-5 avoidance requirements.

EXPERIMENT II

Effects of Various Fixed-ratio Avoidance Criteria

The results of Experiment I demonstrated a general decrement in the response of shocking the rat which appeared to be correlated to the acquisition of avoidance behavior. During conditioning of avoidance behavior, shock frequency progressively decreased to a near-zero level for three subjects while in two other subjects shock response decrement ranged between 50% and 70%. Further, the results under FR-5 avoidance indicate some functional relation between avoidance probability and the number of shock responses.

Experiment II investigates the relationship between the frequency of shock delivery and the rate of avoidance responding. The behavior of shocking the rat was analyzed as a possible function of: (1) avoidance probability and (2) avoidance efficiency for different criteria. To investigate the significance of these two factors, the fixed-ratio requirement for avoidance was manipulated as an independent variable.

METHOD

Subjects

All five subjects of Experiment I were used.

Apparatus

The apparatus described in Experiment I was used.

Procedure

The chain [VI positive reinforcement / concurrent (VI positive reinforcement/FR avoidance)] as described in Experiment I was used as the basic reinforcement schedule. For manipulation of the avoidance criterion, the size of the fixed-ratio avoidance requirement was varied. Ratios were progressively increased to a value that either produced an effect on shock responding or resulted in zero avoidance probability. In both cases, the ratio requirement was then reversed to the previous value before any further manipulations were made. Changes from a lower to a higher ratio were never made if the avoidance probability on a given ratio was less than .8. For the 10-second warning stimulus, the tested fixed ratio values ranged from FR-3 to FR-75. To allow for higher ratio requirements, the length of the warning stimulus was increased to 30 seconds for S 504, S 506 and S 507. A 30-second warning stimulus was presented two minutes and 30 seconds after onset of each reinforcement period which was kept constant at a maximum of 3 minutes. The ratios tested under the 30-second warning signal ranged from FR-35 to FR-200.

Interresponse times (IRTs) for responses on switch (B) during the warning stimulus were used as one index of avoidance performance. Comparisons were made between the obtained IRTs and optimal IRTs calculated for each employed fixed-ratio (maximal IRT possible for successful avoidance under conditions of the 10-second and 30-second warning stimulus). Actual IRTs that were equal to or below the respective statistical optimum were an indication of a 1.0 avoidance

probability. IRTs longer than the required value demonstrated an avoidance probability of less than 1.0.

The second measure of avoidance performance was efficiency of responding. Efficiency was calculated by the following formula:

$$E = \frac{\text{Number of Avoided Time-outs}}{\text{Number of Avoidance Responses During Warning Stimulus}}$$

In the mathematical transformation, the number of responses necessary for avoidance under a given FR schedule was considered one avoidance response. Consequently, the denominator of the efficiency ratio was derived by dividing the total number of switch (B) responses made during the warning stimulus by the respective ratio size.

RESULTS AND DISCUSSION

(1) Avoidance Performance As A Function of Fixed-ratio Size

Figure 5 presents the mean IRTs for avoidance responding for all subjects as a function of the fixed-ratio avoidance requirement

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Insert Figure 5 about here

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and the duration of the warning stimulus. The calculated values do not include sessions before avoidance acquisition. Actual IRTs are plotted against the two statistically derived optimal IRT curves for 10-second and 30-second warning stimulus durations.

A manipulation of the fixed-ratio requirement had systematic effects on avoidance behavior: increments in fixed-ratio requirements appeared to result in a corresponding reduction in avoidance IRTs. The inverse proportionality between ratio size and avoidance

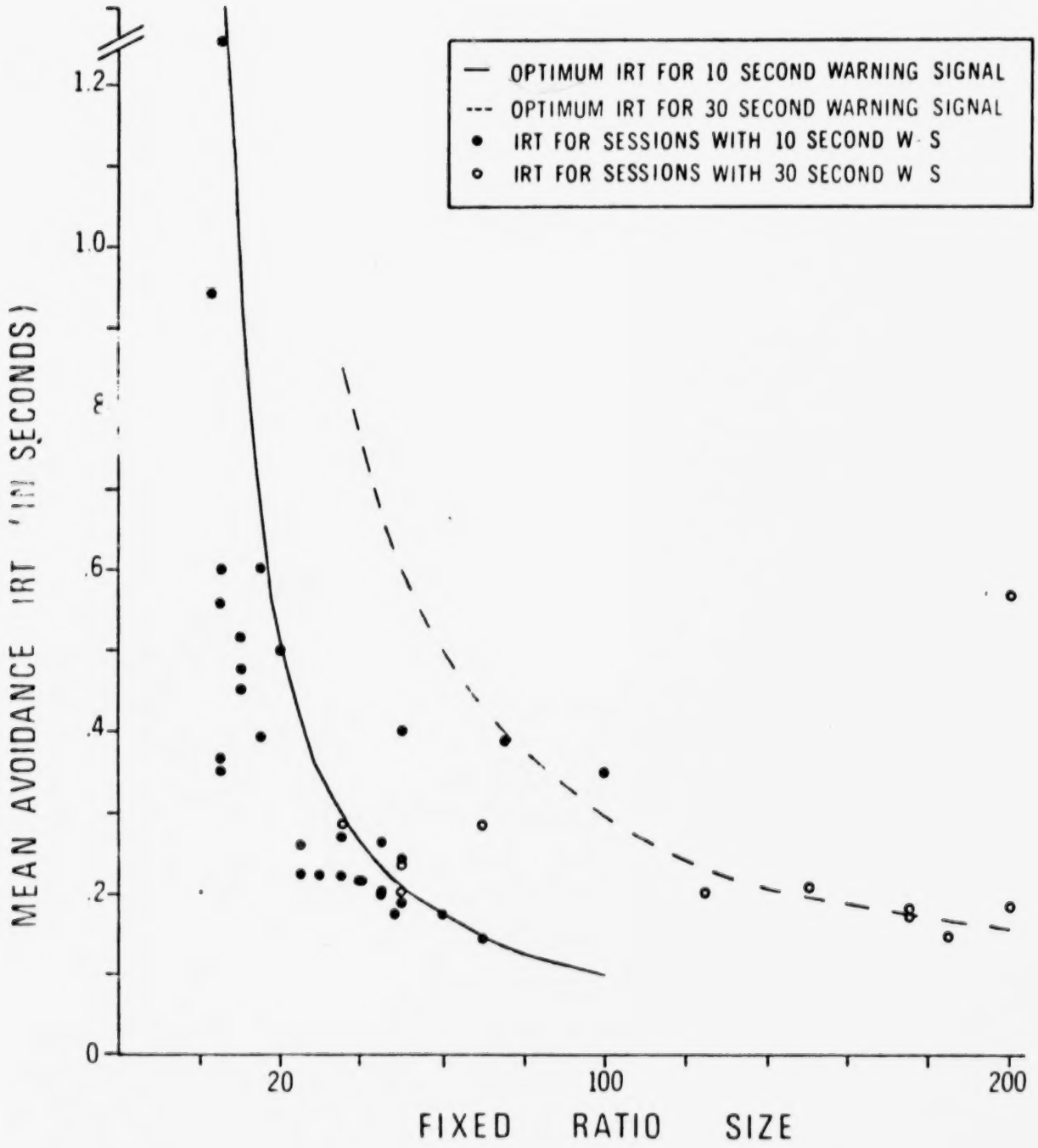

Figure 5

Mean avoidance interresponse times (IRTs) as a function of fixed-ratio requirement and length of the warning stimulus, for all subjects. Actual IRTs obtained under each tested fixed-ratio requirement are plotted against the two statistically derived optimal curves of IRTs for the 10-second and the 30-second warning stimulus. Optimal IRTs were defined as the maximum theoretical time interval between responses that still allowed avoidance of time-out. Only sessions after acquisition are represented by the data points.

IRTs, however, was not monotonic. At extremely high ratios, IRTs had increased in length. The low IRTs, that were necessary for avoidance and were previously observed at lower ratios, were not maintained throughout the long ratio run of a high fixed-ratio requirement. Consequently, avoidance probability was near zero at the extremely high ratios. This change in responding was characteristic for S 504 and S 506 during FR-50, for S 501 during FR-75, and S 505 during FR-100 under conditions of a 10 second warning stimulus. In the case of a 30-second warning stimulus, the same phenomenon was demonstrated on FR-200 by S 504 and S 506.

The increments in IRT length that can be seen in Figure 5 at the extreme ratios appeared excessive if attributed to fatigue effects alone. Rather than fatigue, they suggested a more basic control of avoidance performance: on ratios small enough to permit a high avoidance probability avoidance performance seemed to be a direct function of the reinforcement of short IRTs. According to the immediate conditioning history of certain IRTs for a given ratio, transitions to a higher ratio regularly resulted in nonavoidance in the initial trials of the first sessions. At high fixed-ratios where avoidance probability was 0.0, avoidance behavior was continually subjected to extinction, resulting in an increase in IRTs.

These findings suggested that, because of the more frequent association with extinction, the high avoidance criteria were more likely to have aversive properties than the low criteria. If time-out represented a stimulus that not only generated avoidance behavior, but was aversive enough to function as an antecedent to

aggressive behavior in the form of shocking the rat, the largest number of responses delivering shock to the rat was expected to occur at the higher ratio requirements.

(2) Avoidance Probability, Fixed-ratio Size and Frequency of Shock Responding

Figure 6 presents shock frequencies for sessions with zero (1.0 minute time-out) and 1.0 (no time-out) avoidance probability as a function of the fixed-ratio requirement. It can be seen that for three subjects, S 505, S 501 and S 506, the higher rates of shock responding were associated with an avoidance probability of zero.

Insert Figure 6 about here

For the other two subjects (S 504 and S 507) this was generally not the case. No difference in shock responding was observed as a function of avoidance probability for S 507. S 504's level of shock responding during nonavoidance sessions stayed well below the level consistently maintained during 100% avoidance sessions, except under FR-200 contingencies. When avoidance probability of 1.0 existed, rate of shock delivery to the rat did not appear to be effected by ratio size. However, a 0.0 probability on maximum ratios resulted in increased shock responding for S 504, S 505 and S 506. For example, S 504 emitted a mean of 139.71 responses per session on FR-200 as opposed to 21 responses per session under FR-185. S 505 showed an increase in shock responding from a mean of 66 responses per session under FR-48, to 164 under FR-100. S 506's shock response curve was clearly determined by changes in the warning stimulus: The high

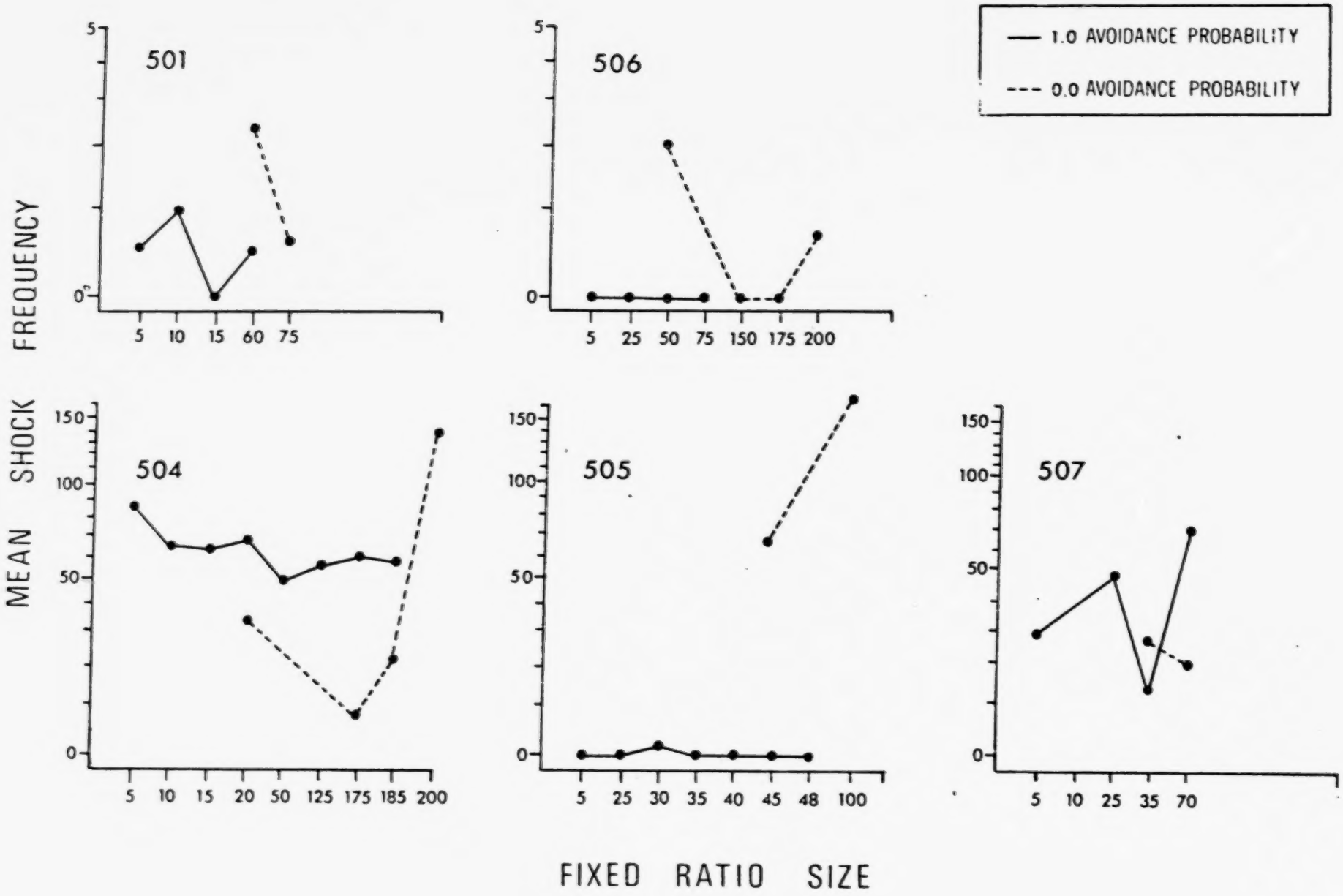

Figure 6

Shock response frequency as a function of fixed-ratio size and avoidance probability. The two curves for each subject present mean shock responses during sessions with 0.0 and 1.0 avoidance probability under the specific ratio requirements tested for each subject. Mean shock responses for FR-5 are calculated from sessions after acquisition only.

shock response rate observed on FR-50 was associated with a 10-second warning period, which was too brief for the subject to meet the avoidance requirements. When the warning stimulus was increased to a duration of 30 seconds, avoidance probability returned to a high level and the rate of shock responding decreased correspondingly. The FR-200 again constituted a requirement that was beyond the subject's capability. As a result of the low avoidance probability, shock responding showed an increment comparable to that previously discussed for FR-50 with the shorter warning stimulus.

Figure 6 demonstrates that frequency of shock responding was partially determined by avoidance probability and fixed-ratio size. However, since both variables were interdependent, any increase in shock behavior could not be attributed to either variable alone. Therefore, it was further analyzed whether avoidance efficiency as a compound index of the r e of avoidance responding, avoidance probability, and ratio size was the critical factor.

Table I presents, for all subjects, probability of relative increments and decrements in shock responding as a function of relative increments and decrements in avoidance efficiency from ses-

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Insert Table I about here

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sion to session. It can be seen that in the cases of three subjects, a relative increase in the number of shock responses corresponded with great regularity to a relative decrease in efficiency. S 504 and S 507, however, do not conform to this pattern. If, in the case of the other three subjects the higher frequency of shock deliveries

Subject	Probability	Increase in Shock Response Frequency	Decrease in Shock Response Frequency
501		.25	.75
504	Increase in Efficiency of Avoidance Responding	.93	.07
505		.4	.6
506		.6	.4
507		.44	.56
501		.64	.36
504	Decrease in Efficiency of Avoidance Responding	.22	.78
505		.7	.3
506		.63	.37
507		.5	.5

TABLE I

Two-factor correlation between relative changes in the frequency of shock responding and avoidance responding efficiency from session to session for five subjects. Efficiency was determined by the formula:

$$E = \frac{\text{number of avoided time-outs}}{\text{total number of avoidance responses during warning stimulus}}$$

The obtained correlation values represent only sessions under regular avoidance contingencies.

during nonavoidance sessions occurred in direct response to the fact that the avoidance criterion was not met, the temporal distribution of shock was expected to be biased toward time-out periods. Figure 7 shows the percent distribution of shock responses during reinforcement, warning and time-out periods for sessions of 0.0 and 1.0 avoidance probability. A reinforcement period in this case is de-

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Insert Figure 7 about here

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fined as the length of time during which reinforcement was available, minus the length of the warning stimulus. It is apparent that during the avoidance sessions, nearly all shock responses occurred during reinforcement periods. During nonavoidance sessions, however, S 501 was the only subject who delivered his highest percentage of shocks during the time-out periods. The other three subjects responded on the shock switch more during warning or reinforcement periods than during time-out. Since there is a high degree of shock-responding variability among subjects, functional statements concerning schedule-specific variables and their effect on the rate at which a subject would shock a rat have to be qualified by subject-specific factors.

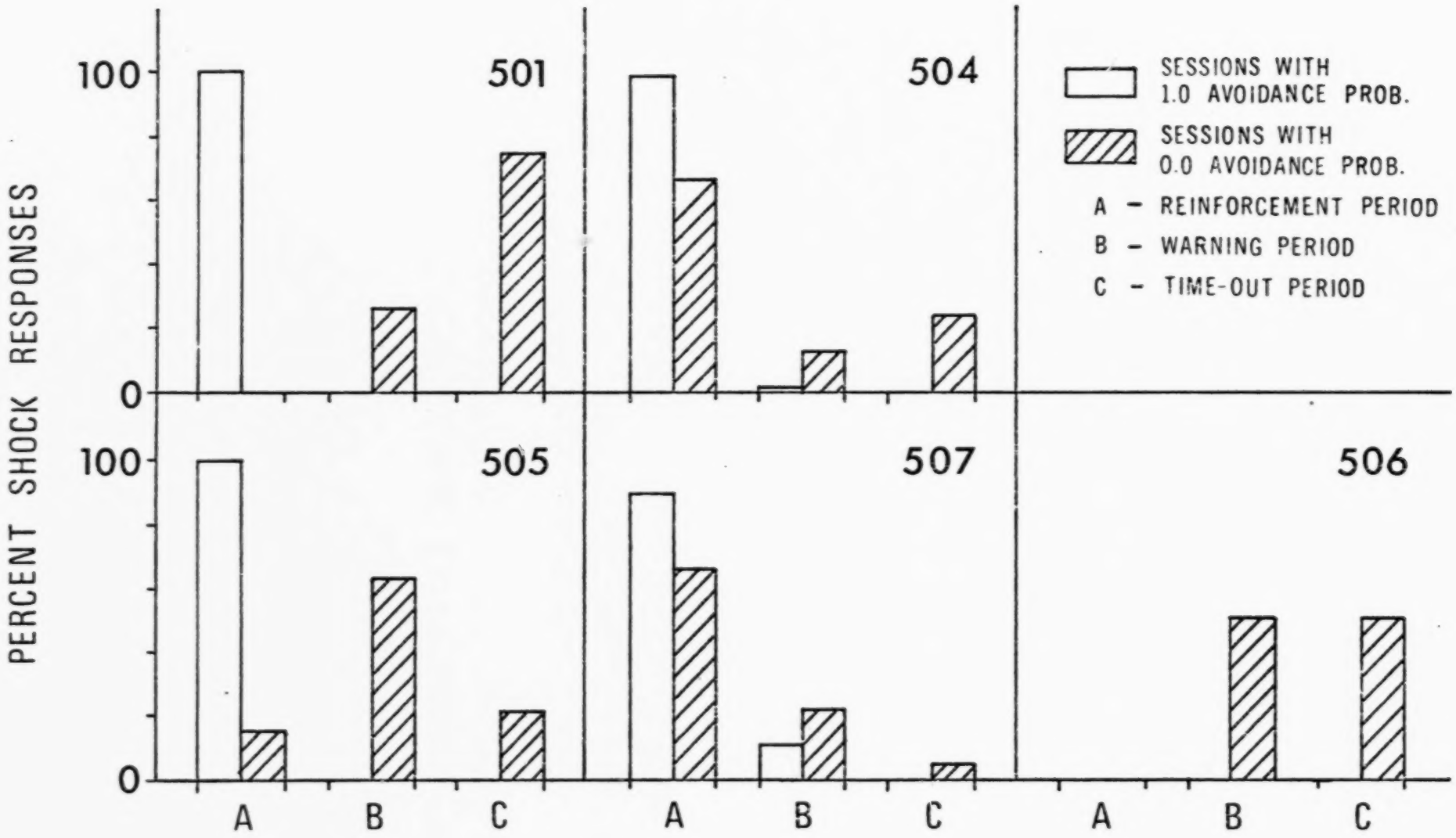

Figure 7

Percentage distribution of shock responses during reinforcement, warning and time-out periods. Values are presented for sessions with 0.0 and 1.0 avoidance probabilities across all tested FR schedules. Only sessions of normal avoidance contingencies are included.

EXPERIMENT III

Shock Delivery and Shock Opportunity

The results of Experiment II showed that three subjects (S 501, S 505 and S 506) shocked rats more during nonavoidance than during avoidance sessions. It was suggested that not only avoidance probability, but also avoidance criterion and avoidance efficiency were critical factors. As Figures 6 and 7 demonstrated, two subjects (S 504 and S 507) appeared not to be controlled by the listed variables in the same way as the other three subjects. The basic rate of shock responding during avoidance sessions was higher for S 504 and S 507 than the rates for any other subjects. In further contrast, S 504's shock responding during nonavoidance sessions was not above, but below, the level maintained during avoidance sessions, with the exception of his responding at a fixed-ratio of 200. S 507 did not show a differential pattern of shock responding that could be attributed to either fixed-ratio size or avoidance probability.

In Experiment III, the opportunity to shock the rat was manipulated for S 504 and S 507 in order to further investigate factors that determined their response rate on the shock switch.

METHOD

Subjects

S 504 and S 507, who had been employed as subjects in Experi-

ment I and II, were used for further study.

Apparatus

The apparatus described in Experiment I was used. Electric shock could be disconnected from switch (C) or be connected to switch (B) and (C) simultaneously. The two rats used as target objects had never been exposed to shock prior to the start of Experiment III.

Procedure

The subjects were conditioned on the avoidance of time-out from positive reinforcement schedule as described in Experiment I. The duration of the warning stimulus was 30 seconds. A fixed-ratio of 125 responses of switch (B) for S 504 and ratios of 35 and 70 responses for S 507 during the warning stimulus were required to avoid time-out.

I. With S 504, the shock variable was tested by disconnecting switch (C) from the shock source and subsequently reinstating the shock opportunity.

II. The opportunity to shock the rat was tested as a variable for S 507 by connecting shock to the avoidance switch (B), in addition to having it associated with switch (C), so that each response on either switch would shock the rat.

Experimental conditions were introduced after avoidance performance under FR-125 and FR-35 was observed to be stable.

RESULTS AND DISCUSSION

I. By having shock to the rat associated with S 507's responses on both switch (C) and the avoidance switch (B), it was expected that his response rates on both switches would show a decrement as compared to regular sessions. Figure 8 indicates that this hypothesis was confirmed at a high fixed-ratio requirement, but not

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Insert Figure 8 about here

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at a low ratio. The upper portion of the figure depicts rates of avoidance responses on switch (B) and the lower portion depicts responses on the shock switch (C). Both are presented as a function of FR-35 and FR-70. The solid lines are representative of the regular avoidance sessions, while the dashed lines represent sessions during which avoidance responses delivered shock to the rat. Under regular avoidance conditions, there was a slight increase in rate of avoidance responses at FR-70. When avoidance responses simultaneously delivered shock to the rat, their rate decreased by about 90 responses/minute on FR-70. Correspondingly, responses on the shock switch (C) decreased in frequency on FR-70, as opposed to a regular avoidance session where the ratio increase to FR-70 had produced an increment 3 times the rate observed on FR-35. The magnitude of the avoidance requirement did prove to be a critical factor in establishing that S 507's basic rate of responding on the shock switch was functionally connected to elements of the avoidance schedule. However, the subject's pattern of responding did not allow

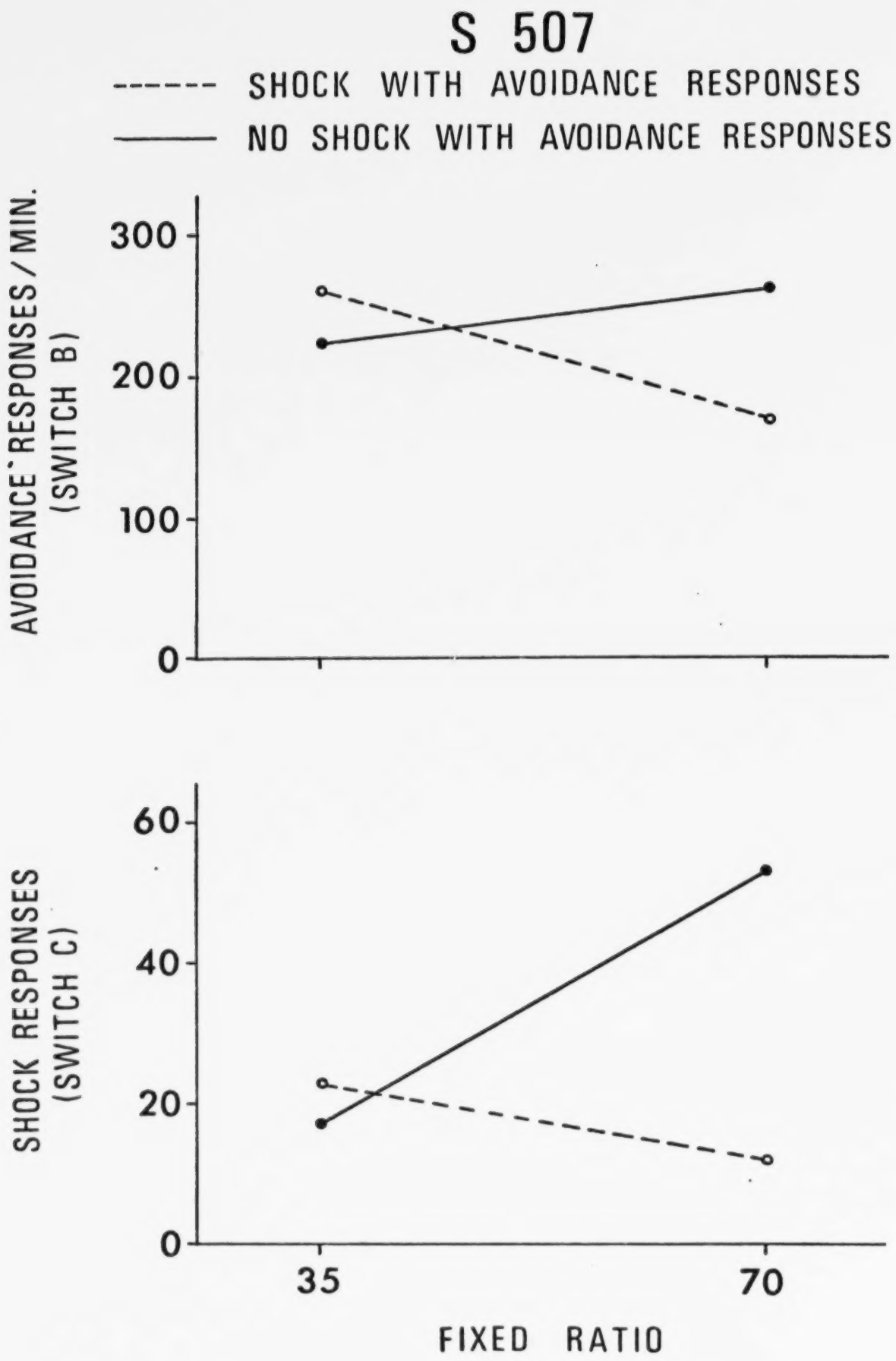

Figure 8

Responses on switch (B) and (C) under FR-35 and FR-70 regular avoidance contingencies and conditions, during which avoidance responses [responses on switch (C)] delivered shock to the rat.

for a more precise identification of the variables which determined his basic level of shock responding as seen in Figure 6. A detailed analysis of the temporal relation between shock responses and other events occurring during a session showed that shock responses occurred nonsystematically and apparently were not controlled by any programmed preceding or following event.

II. The elimination of the opportunity to deliver shock to the rat by means of pressing switch (C) did not have any apparent effect on S 504's rate of responding on the switch. Figure 9 shows cumulative records of responses on the toggle switch (C) for two sessions, with and without shock availability. These records indi-

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Insert Figure 9 about here

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cate no notable difference in the rate or the pattern of responding on switch (C) between the two conditions. Thus it seems that the high basic response rate on switch (C), appearing in Figure 6 in the cases of all avoidance ratios, was not functionally dependent upon the unique association of switch (C) with shocking the rat. The fact that shock rates of S 504 were higher during perfect avoidance sessions than during nonavoidance, suggested a possible association of shock with positive reinforcement or other events that were reduced in frequency during nonavoidance sessions. Figure 10 presents a probability distribution of the temporal position of shock responses

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Insert Figure 10 about here

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with regard to other events. The data represent five regular ses-

S 504

FR 125

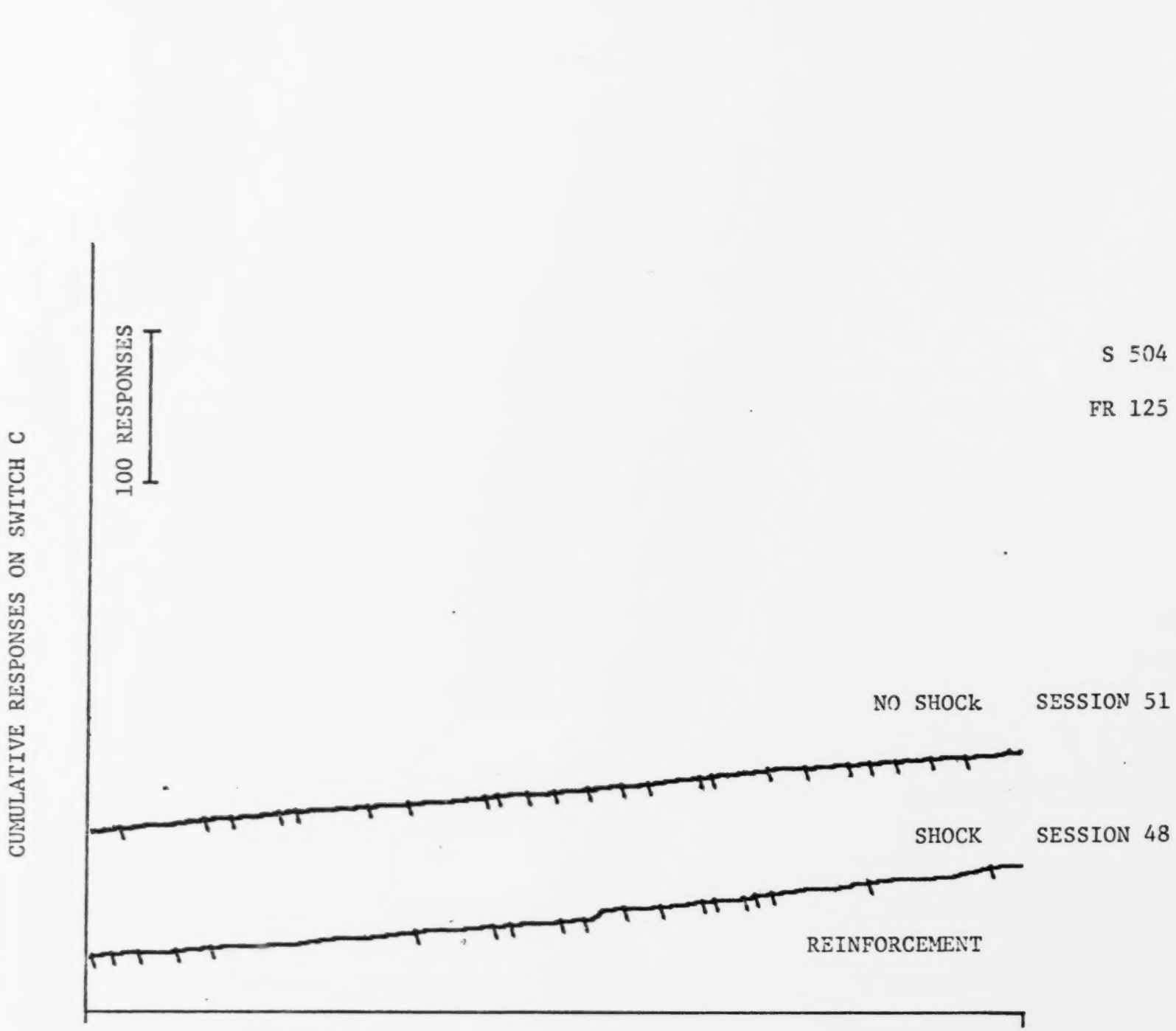

Figure 9

Representative cumulative responses of S 504's responding on switch (C) under conditions in which each response delivered shock to the rat (session 48) and under conditions in which switch (C) was disconnected from the shock sourceon session 51. Diagonal downward deflections of the pen represent positions of positive reinforcement, for responses on switch (A).

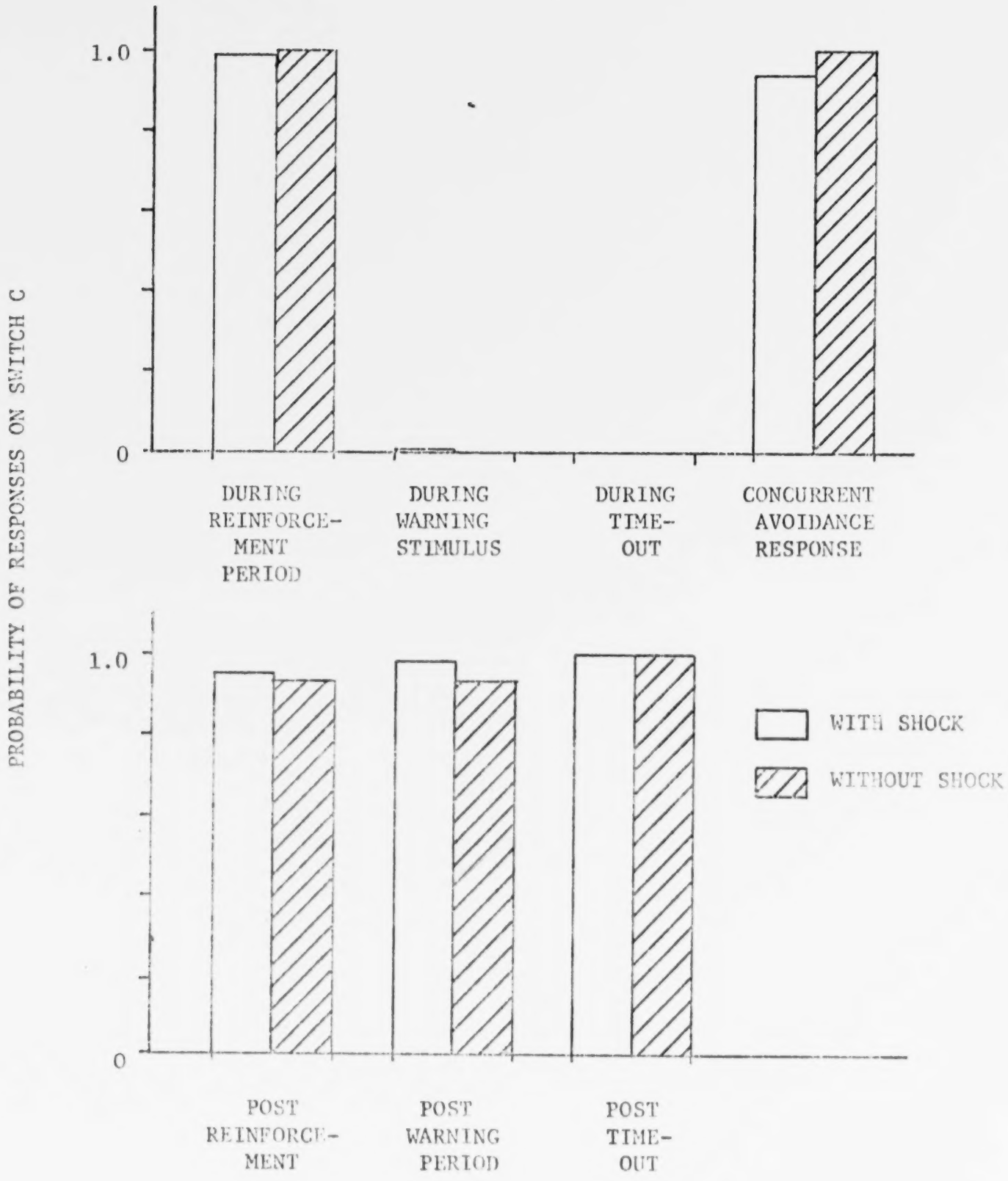

Figure 10

Probability of temporal position of responses on switch (C) under conditions of shock and no-shock delivery to the rat by each press of the switch. The upper portion of the figure depicts shock response probabilities during reinforcement, warning and time-out periods, and the probability of one avoidance response occurring concurrently with the shock response. The lower portion demonstrates probabilities of shock responses occurring during the post-reinforcement pause, directly after the termination of the warning stimulus and time-out. Only those responses are included that were the first response after the designated event.

sions and three sessions during which the switch (C) was disconnected from the shock source. As the upper portion of the figure demonstrates, the probability of shock responses occurring during reinforcement periods was nearly 1.0. None of the shock responses were observed during time-out periods, and only a small fraction during the presence of the warning stimulus. The lower portion of the figure indicates at what points during a reinforcement period shock responses were emitted. It portrays the probability of shock responses occurring directly after a warning stimulus, after a time-out period or during the long post-reinforcement pause typical for this subject. The distribution includes only those shock responses that were emitted as the first response after the three events, before the subject made a response on the avoidance switch or resumed responding on the reinforcement switch for the next reinforcement. The analysis showed that S 504 regularly delivered a shock after time-out and that the probability of shock after each reinforcement and warning period was similarly high at 0,96 and 0.975, respectively. This distribution accounts for the major portion of all the shock responses during the included sessions. The rest occurred randomly during the VI-responding. Responding on switch (C) without shock did not deviate significantly from the mentioned pattern during regular sessions. These data explain the lower number of shocks that were delivered to the rat by S 504 during sessions with a higher total of time-out, as shown in Figure 6. Each instance of nonavoidance of time-out meant a maximum of 10% reduction in both probability of reinforcement and warning stimulus presentation,

since the next reinforcement period was postponsed by the time-out duration. In the case of a nearly 1.0 correlation between the reinforcements and shock responses, as well as between warning periods and shock responses, 15 minutes of time-out during a 30-minute session would reduce the probability of shock responses occurring after these events to 0.5.

These systematic correlations between schedule-inherent events and shock responses serve to qualify the theoretical assumption that all responses of the shock switch be considered aggressive responses. Such a restriction is supported by a second observation: In the case of S 504's shock behavior, there is a 0.94 to 1.0 probability that each response on the shock switch is accompanied by one concurrent response on the avoidance switch, before the subject again presses switch (A) for the next reinforcement.

Both response characteristics of S 504 would suggest that although shock responses may be regarded as an indication of aversive qualities of the used avoidance of time-out schedule, they are not a unique expression of it. An interpretation that regards the two correlating responses on switch (B) and switch (C) as functional in terms of producing a stimulus change, seems to be more appropriate than a categorization of all responses on the shock switch as aggressive responses. The fact that S 504's responding differed basically from S 501, S 505 and S 506, who were discussed in Experiment II, suggested this qualification and differentiation.

EXPERIMENT IV

Magnitude of Negative Reinforcement

Experiment II and the data for S 507 of Experiment III have shown that elements of avoidance of time-out from positive reinforcement would induce some subjects to deliver electric shock to a rat, although no explicit reinforcement contingencies were programmed for this behavior. It was demonstrated that the rate of shock responses was highest under avoidance requirements that resulted in a high frequency of time-out. Since each instance of nonavoidance produced a reduction in probability of positive reinforcement, responding suggested some relation between shock responses and the number of obtained or available reinforcements. To assess this relationship, two procedures were employed in which nonavoidance not only reduced the availability of positive reinforcement, but actually resulted in the loss of already obtained reinforcement.

EXPERIMENT IVa

Avoidance of Actual and Potential Loss of Positive Reinforcement

METHOD

Subjects

The subject (S 504) had been used in the three previous experiments. He had been conditioned on the avoidance schedule described in Experiment I, with avoidance requirements ranging from CRF to FR-200.

Apparatus

The basic characteristics of the apparatus used were described in Experiment I. An additional counter mounted above light (b_2) gave a continuous record of the number of nonavoidance trials.

Procedure

S 504 was again subjected to the chain [VI positive reinforcement / concurrent (VI positive reinforcement/FR avoidance)] schedule described in Experiment I. Avoidance criterion was 185 responses on switch (B) during the 30-second warning stimulus light (b_1). Reinforcement magnitude was 1 nickel. After initial testing on the FR-185 avoidance schedule, the counter was introduced on the face of the response console. It provided the subject with a continuous record of the number of time-out periods that were not avoided during a particular session. The following information was

given to the subject:

> "Do you see this counter? From now on the counter will record how often you did not press the middle switch enough times. It will count up one whenever all the lights go off."

After the counter had been tested for its effect, an additional contingency for nonavoidance was introduced. For each time-out period the subject did not avoid, 15¢ of the money he had already earned during previous reinforcement periods was subtracted. Instructions about the procedure change were read to the subject:

> "From now on you will have to give me back 15¢ for each time the two lights go off. You will have to pay that back to me at the end of the session. The counter here will tell you how often the lights went off and thus how much money you owe me. Just multiply the 15¢ by the number on the counter and you will know how much you will have to give back to me at the end of the session."

After the end of two sessions on the new contingency, the ratio requirement was increased to FR-200.

RESULTS AND DISCUSSION

The results again demonstrated differential effects of the tested variable on a different fixed-ratio. Figure 11 presents two cumulative records of S 504's shock responding under added response contingencies. The records are taken from the first ses-

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Insert Figure 11 about here

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sions on FR-185 and FR-200, respectively. Both sessions are non-avoidance session. As can be seen from this figure, S 504's shock responding under FR-185, when he had to pay 15¢ for each time-out

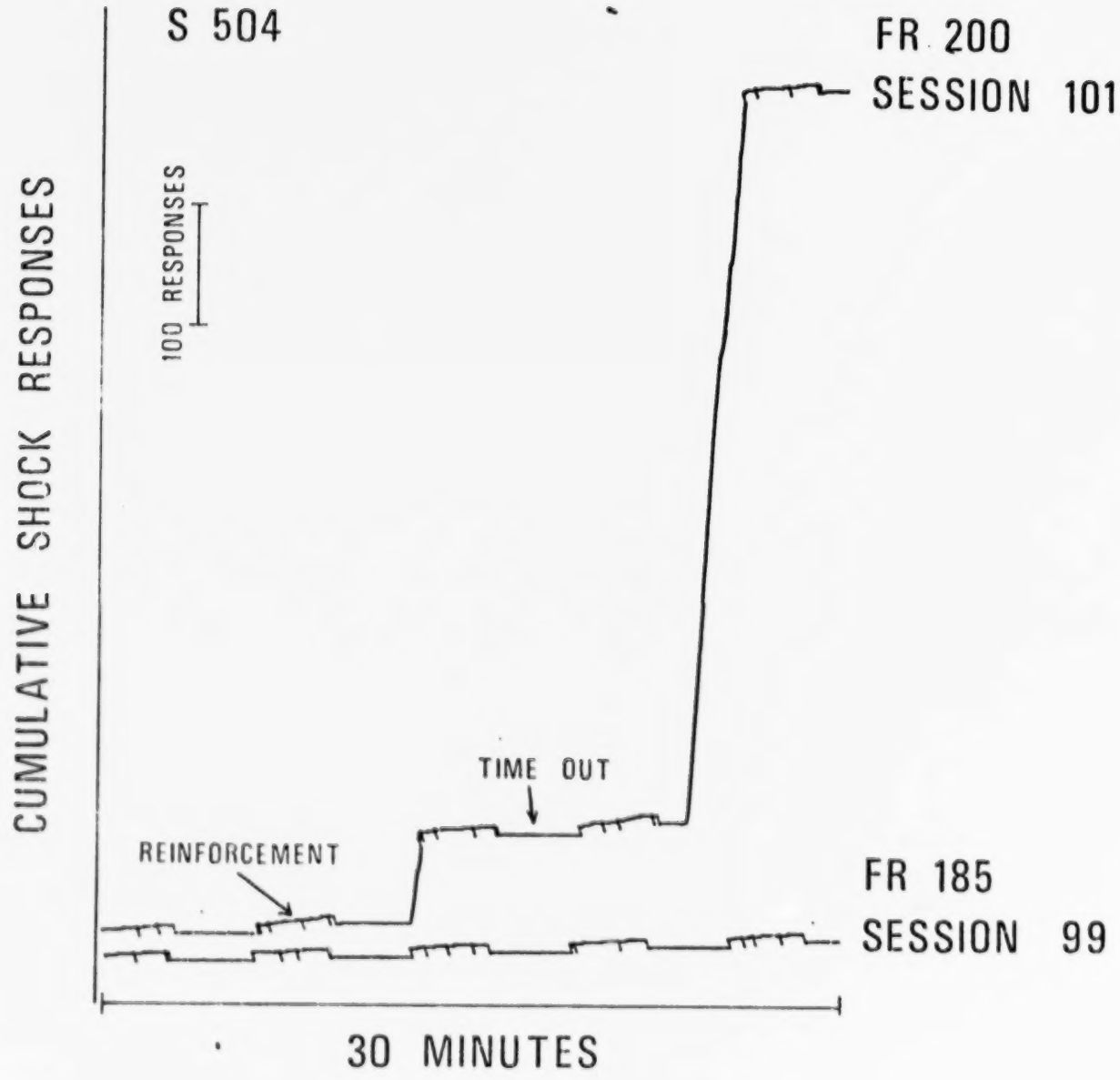

Figure 11

Sample cumulative records of shock responding for S 504 under added cost contingencies for each time-out. S 504 had to pay 15¢ for each time-out that was not avoided. The two presented sessions (99 and 101) are the first sessions under the respective fixed-ratio requirement of FR-185 and FR-200. Time-out periods (TO) are indicated by downward deflections of the recording pen held into position for the duration of the time-out. Diagonal hashmarks ((R) indicate the position of positive reinforcements for responses on switch (A).

did not deviate from responding under the original avoidance schedule. No shock responses occurred during time-out. Distribution of shock responses during reinforcement periods remained the same as that depicted in Figure 10. When the avoidance requirement was increased to FR-200, a drastic change in shock responding was observed. The total frequency of shock responses increased from 21 to 682 during this session. The largest portion by far of these shocks to th rat was delivered during two time-out periods in long bursts of responding. The distribution of shock responses during reinforcement remained constant.

In terms of the preceeding observation, this session deviated significantly from the nonavoidance under regular avoidance contingencies. The fact that most shocks occurred during time-out indicated a different type of behavior control than the one suggested by the temporal distribution in Figure 7. It did not appear to be a phenomenon produced solely by a too-high avoidance criterion; rather, a high response requirement in combination with the potential and actual loss of all reinforcement seemed to be the critical factor.

EXPERIMENT IVb

Avoidance of Withdrawal of Positive Reinforcement

In Experiment IVa, the stimulus conditions that produced a high rate of shock delivery to the rat were a compound of several potentially aversive elements: (1) a high work requirement, (2) a reduction in reinforcement availability, and (3) the withdrawal of money that had previously been earned. The last two factors both contributed to a reduction in the total amount of reinforcement per session. Experiment IVb investigated whether the withdrawal of money in a discrete trial avoidance session was sufficient to produce effects on the rate of shocking the rat similar to those observed previously.

METHOD

Subjects

One male (S 604) and one female (S 601) undergraduate college students served as subjects. Both were experimentally naive.

Apparatus

The apparatus described in Experiment I was used in a modified form. Figure 1 illustrated the elements contained in the face of the response console. Only switches (B) and (C) and lights (b_1) and (b_2) were present as response manipulanda and stimulus lights respectively. The function of both the switches and light (b_1) were the same as in Experiment I. Light (b_2) was flashed for

0.2 seconds duration whenever the avoidance criteria were met. A counter (D) gave a continuous record of the number of nonavoided trials. The reinforcement dispenser was disconnected and the reinforcement container was removed.

Procedure

The results consisted of a discrete trial discriminated avoidance procedure, with the loss of a fixed amount of money as the event to be avoided. At the beginning of each session, the subject received $1.50. A warning stimulus, light (b_1), was presented every 30 seconds for a maximum duration of 30 seconds. Completion of a fixed number of responses on switch (B) during this time terminated the warning stimulus and avoided the loss of 5¢. Avoidance was indicated by a 0.2-second flash of the red light (b_2). If the criterion was not met, the warning stimulus would terminate after 30 seconds and the counter on the face of the response console would count this trial as not avoided, A session consisted of 30 trials. At the end of the session, the subjects had to return to the experimenter the total amount of the money lost. The following information was read to the subjects prior to the start of the experiment:

> "All you have to be concerned with are these two switches [The experimenter pointed to switch (B) and switch (C).] These two lights [the experimenter pointed to lights (b_1) and (b_2)] and this counter [the experimenter pointed to counter (D)]. Your task will be to press this bottom button when the light near it is on. If you had pressed it enough times by the time it goes off, the red light will flash. If you did not press it enough times, the counter will count up one. That means that you owe me 5¢. For each count on the counter, you will owe me 5¢ and you will have to give back to me the

> amount you owe me by the end of the session. If the counter shows zero at the end of the session, you can keep all your money. Please do not manipulate the counter and stay in this room until I come to let you out."

During Phase I, the subjects were conditioned on FR-50 avoidance. When performance appeared to be stable, the requirement was increased to FR-200. Subsequently, subjects were returned to the FR-50 schedule. During Phase II, S 604 received $4.50 before each session. The money to be lost upon each instance of not avoiding was 15¢. The ratio requirement was again increased from FR-50 to FR-200. Before the start of this phase, the subject received the following information:

> "From now on you will get $4.50 before each session but you will have to return to me 15¢ for each count on the counter,"

RESULTS AND DISCUSSION

Figure 12 shows, for subject 601, the probability of avoidance and the number of shock responses as a function of fixed-ratio requirement. Under FR-50, the subject maintained a 1,0 avoidance probability, virtually no shocks were delivered to the rat after the first two sessions. When the avoidance criterion

Insert Figure 12 about here

was raised to 200 responses, avoidance probability declined to zero. Concurrently, the subject started pressing the shock switch at a rate of 2 to 14 responses per session. A reversal to the FR-50 schedule again eliminated all shock responses and the subject re-

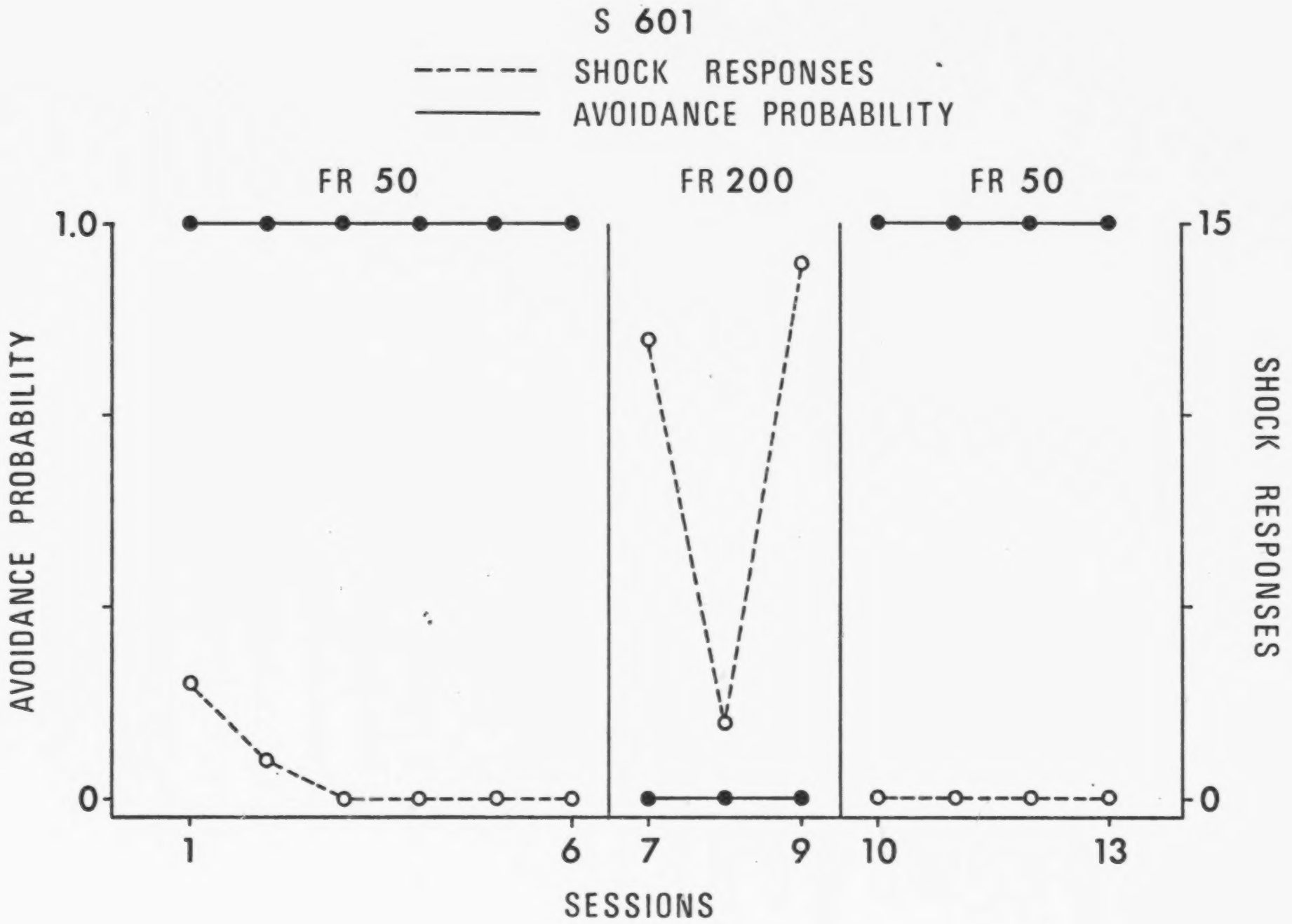

Figure 12

Probability of avoidance of withdrawal of positive reinforcement responses and number of shock responses as a function of FR-50 and FR-200 avoidance for S 601.

turned to 100% avoidance.

A detailed analysis of the temporal position of shock responses within the intertrial interval (ITI) and the warning period identified the specific elements of the FR-200 avoidance schedule that produced an increase in shock responding. Figure 13 indicates that the delivery of shock, during the three sessions under FR-200,

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Insert Figure 13 about here

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was not equally likely at all points of the ITI or warning period. Probability of shock responses was highest during the last ten seconds of the warning period and the first 10-second portion of the ITI. Keeping in mind that during these sessions, the avoidance efficiency was zero, it is plausible to consider the shock responses that occurred during the first portion of the ITI a direct function of the failure to avoid. As demonstrated by the higher total percentage of shock responses during the warning signal, responses on the shock switch were interspersed with fixed-ratio avoidance responding and occurred at a higher frequency during the end of a ratio run than during earlier stages.

Performance of S 604 under the same conditions was characterized by a zero-shock response rate during sessions of FR-50 and FR-200 as well, even though on the FR-200 schedule the subject did not avoid. The only shocks ever delivered by this subject occurred when the amount of cost per nonavoided trial was raised from 5¢ to 15¢. Since the subject discontinued his participation, experimental conditions could not be reversed to the original avoidance con-

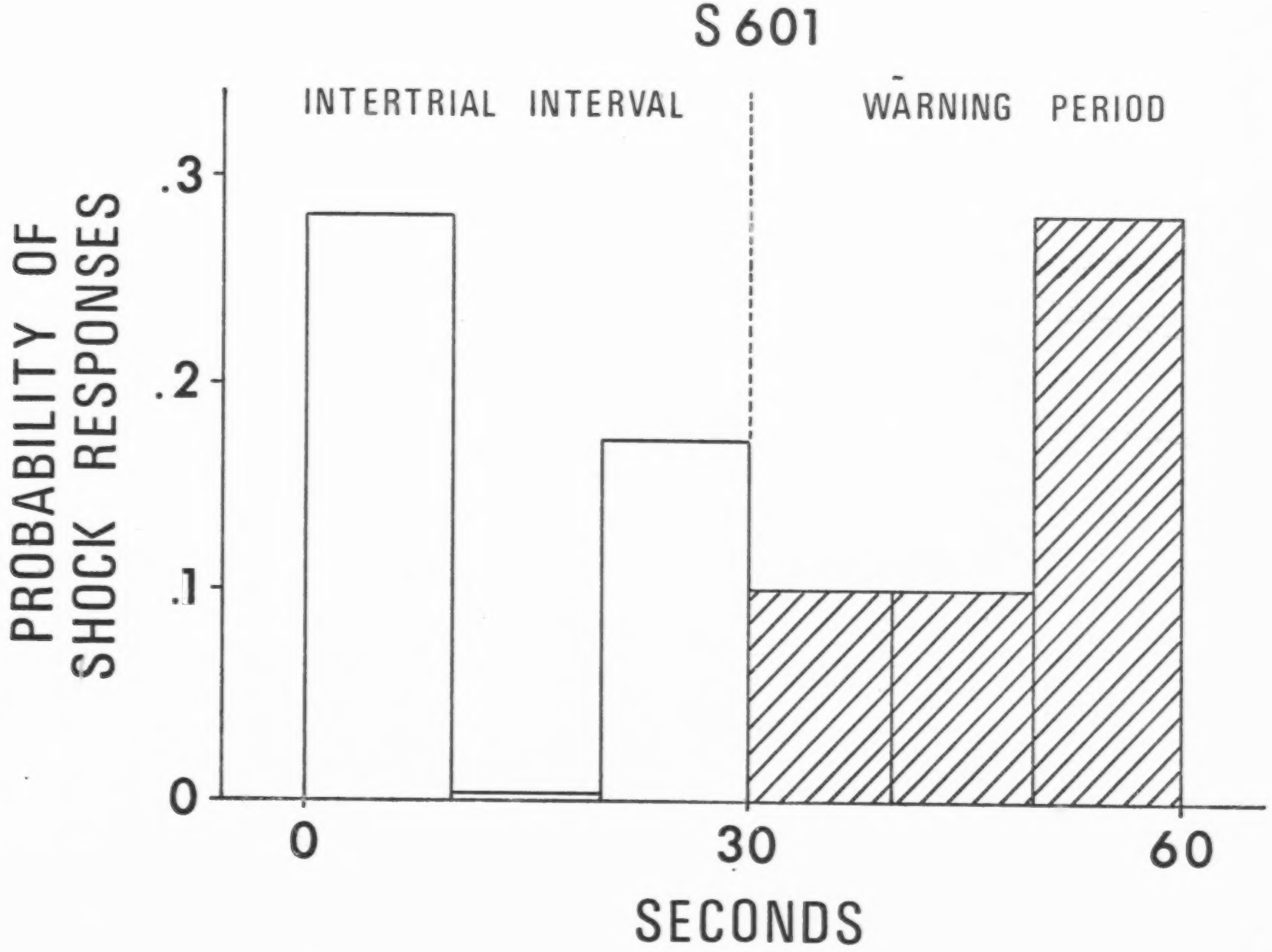

Figure 13

Probability distribution of temporal position of shock responses during intertrial intervals and warning periods for S 601. Values represent average shock response probabilities for the three 101-200 sessions. All three sessions were nonavoidance sessions.

tingencies. Thus, it could not be confirmed that the increment in shock responding was due to an intensification in contingencies for nonavoidance.

EXPERIMENT V

Extinction of Positive and Negative Reinforcement

Two procedures had been employed in Experiment IV to assess the hypothesis that the higher rates of delivering shock to a rat under conditions of extremely high avoidance criteria were the result of a maximization in potential, and actual, loss of reinforcement. Both procedures indicated the existence of a high correlation between the rate of shock responding and the frequency and magnitude of withdrawal of obtained reinforcement. Only in the case of S 604, however, do the results point to the actual decrement in reinforcement as the critical factor. In the case of the other two subjects, the larger portion of recorded shock responses was connected to avoidance requirements which consistently could not be fulfilled. These findings are in accordance with the results of Experiment II. Thus, it appears that higher rates of shocking the rat occurred whenever the subjects could predict that experimental conditions would not allow for a high avoidance probability.

Experiment V employed two procedures to investigate whether a frustration of avoidance behavior that was not under the subject's control was responsible for the relative increase in shock responding occurring at the high requirements.

METHOD

Subjects

Three male undergraduate college students (S 504, S 505 and S 507) were used. They had been tested in previous experiments on the rate of shocking the rat under different criteria for avoidance of time-out from positive reinforcement.

Apparatus

The basic characteristics of the apparatus were described in Experiment I. To make the avoidance switch temporarily inoperative, the switch handle was prepared to break during rapid and repeated manipulation. During extinction sessions, the reinforcement dispenser was disconnected.

Procedure

All subjects were conditioned under the chain [VI positive reinforcement / concurrent (VI positive reinforcement/FR avoidance)] schedule of reinforcement that was described in Experiment I. For S 504 and S 507, the maximum duration of the reinforcement period was 3 minutes. A 30-second warning stimulus was presented 2 minutes and 30 seconds after the onset of each reinforcement period, and was followed by 3 minutes of time-out in the case of failure to avoid.

For S 505, duration of the warning stimulus was 10 seconds, while the maximum length of reinforcement periods and the fixed length of time-out were 1 minute each.

The first extinction phase, consisting of 4 sessions during which no positive reinforcement was delivered for responding on switch (A), was initiated for S 507 after stable avoidance responding under FR-70 was established. After a reversal from extinction to FR-70, S 507 was subjected to a second extinction which was again followed by a reversal to the FR-70 baseline. The subject was not informed of the extinction procedure. Eventual questions posed to the attending assistant were diverted by his stating that he had no information about anything concerning this matter, and that the experimenter was not accessible for questioning.

S 504 encountered a single extinction session on FR-200 as a result of a malfunction in reinforcement delivery. For S 505 also, the first breakdown of the avoidance switch (B) was due to a malfunction during session 66, while he was responding to avoid on FR-48. After 12 subsequent sessions of regular avoidance, malfunction of switch (B) was systematically scheduled for the following four sessions. The avoidance switch was prepared such that its handle would break off during the second half of the session, making it impossible for the subject to further operate it in a way which would record responses.

The first session of malfunction was explained to the subjects as accidental breakdown. After each following breakdown, the experimenter apologized to the subjects by pointing out the apparent inadequacy of the technical service in attempting to repair the switch permanently. Subsequent to this period of malfunction, the regular FR-48 avoidance procedure was reinstated for 2 sessions.

RESULTS AND DISCUSSION

Withholding of positive reinforcement for responses on switch (A) produced a significant change in the rate of S 507's responding on the shock switch. Figure 14 presents cumulative records of shock responding during sessions of extinction as compared to sessions in

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Insert Figure 14 about here

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which reinforcement was available. The left portion of the figure depicts the progressive increase in shock responding across the four sessions of the first extinction phase. The extinction sessions are compared with session 71 which, with a total of 74 shock responses, was representative for S 507's rate and pattern of responding under FR-70. It can be seen that rate of shock responding during the first and third extinction sessions had changed little. The fourth extinction session, however, produced a dramatic increase to 998 shocks delivered to the rat which by far represent the largest number of shocks ever delivered by subject S 507.

The restoration of positive reinforcement contingencies during session 14, as shown in the right portion of Figure 11, resulted in a decrement in shock-response frequency to a level previously noted for session 8. When subject 507 was subjected to the second extinction phase on session 16, the previously observed effects of shock responding were replicated on a smaller scale The frequency of shock responding increased from 83 (session 14) to 494 (session 16). Although this high level was not maintained during

the subject's subsequent session, a rate of 205 shock responses during session 17 still exceeded the average rate represented by sessions 8 and 14. A reintroduction of positive reinforcement again produced an immediate decline in shock response rate to 33 responses during session 18 (not shown on the graph).

In addition to the discussed acceleration in the rate of shock delivery, Figure 14 shows a significant change in shock response pattern as a function of extinction of responses on switch (A). Under conditions of positive reinforcement availability, shock responses were distributed equally throughout the entire session. When reinforcement was withheld, shock responses were delivered to the rat in long bursts of responding separated by pauses of no shock responding at all. This modification in shock distribution occurred on the first day of extinction and was most pronounced during sessions 13 and 16, which were the last and the first session during extinction phases I and II, respectively.

Another phenomenon closely connected to extinction of positive reinforcement was a deterioration in avoidance performance. Before S 507 was subjected to extinction, he had maintained a stable 1.0 avoidance probability. During both phases of extinction, avoidance probability ranged from as low as 0,0 to no higher than 0.8. This is shown in Figure 14 by each downward deflection of the recording pen, held in position for the duration of time-out. It is apparent that, in contrast to the extinction sessions, both reinforcement sessions (session 8 and 14) were characterized by 100% avoidance.

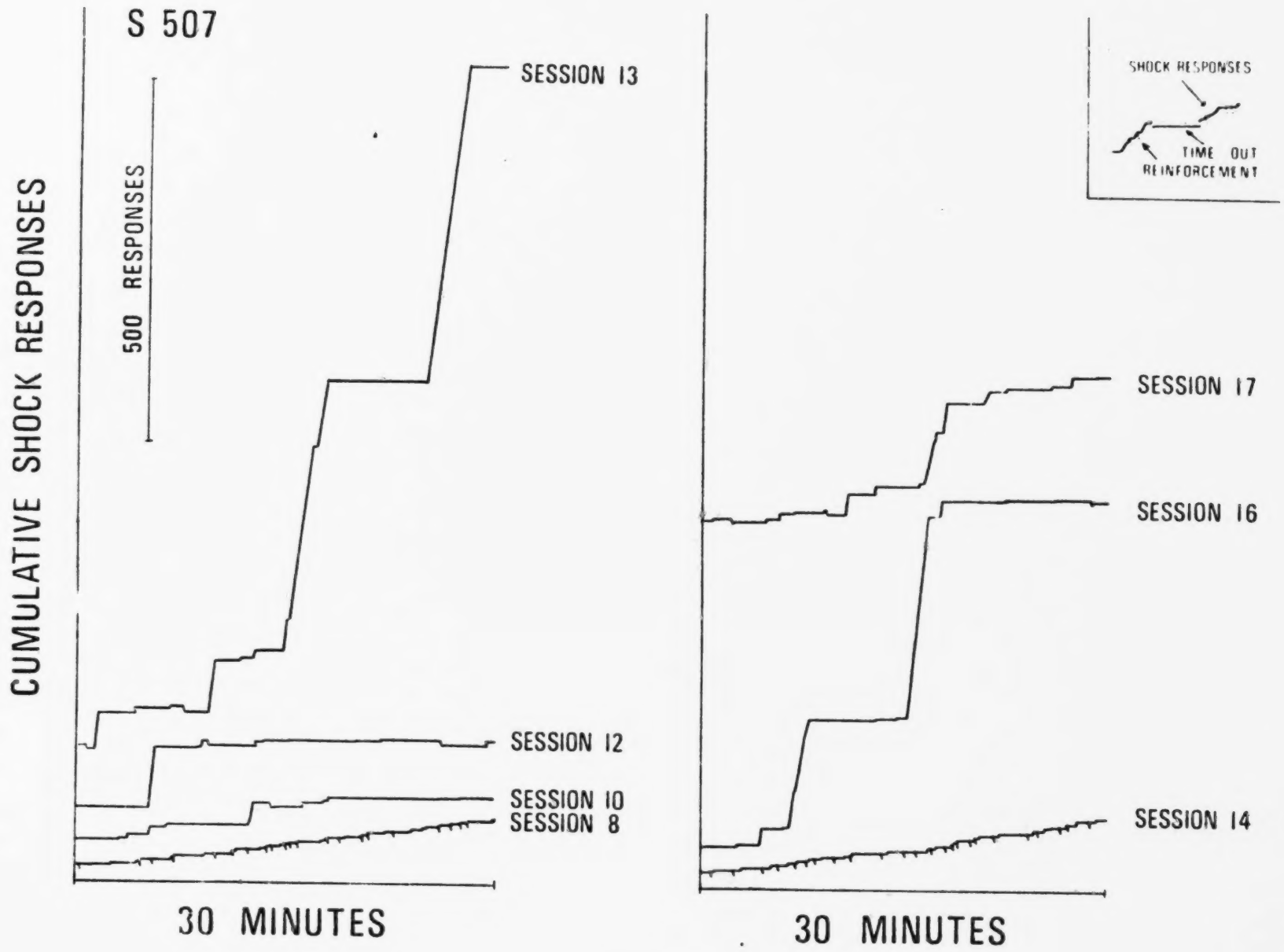

Figure 14

Cumulative records of S 507's shock responding under positive reinforcement and extinction of responses on switch (A). The left and right portion of the figure represent sessions under Extinction I and Extinction II respectively.

The expected progressive decline in responding on switch (A) as a function of extinction was observed only during the first two sessions. The other four sessions did not deviate from the level of responding that had been consistent throughout regular avoidance sessions.

The behavior of S 507 under extinction indicated that in his case, rate of delivering shock to a rat was affected by the availability of positive reinforcement. Withholding of reinforcement for responses on switch (A) produced large increments in shock response rates. The effects appeared to be cumulative and twofold: notable changes in distribution of shock responses did not occur until after the second session on extinction. Increments were maximal by the fourth session. This session was characterized by a progressive acceleration in shock responding frequency.

Similar cumulative effects within sessions were demonstrated by the cumulative response records for S 504 and S 505, presented in Figure 15, when avoidance probability on high ratio requirements

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Insert Figure 15 about here

---

was zero, and under conditions of extinction or avoidance-handle malfunction. There appeared to be no difference between S 504's shock responding under FR-200 avoidance with and without positive reinforcement for responses on switch (A) (sessions 62 and 57 respectively). In both sessions presented in the upper portion of Figure 15 the majority of shocks were delivered to the rat in rapid bursts of responding during the last two minutes of the session.

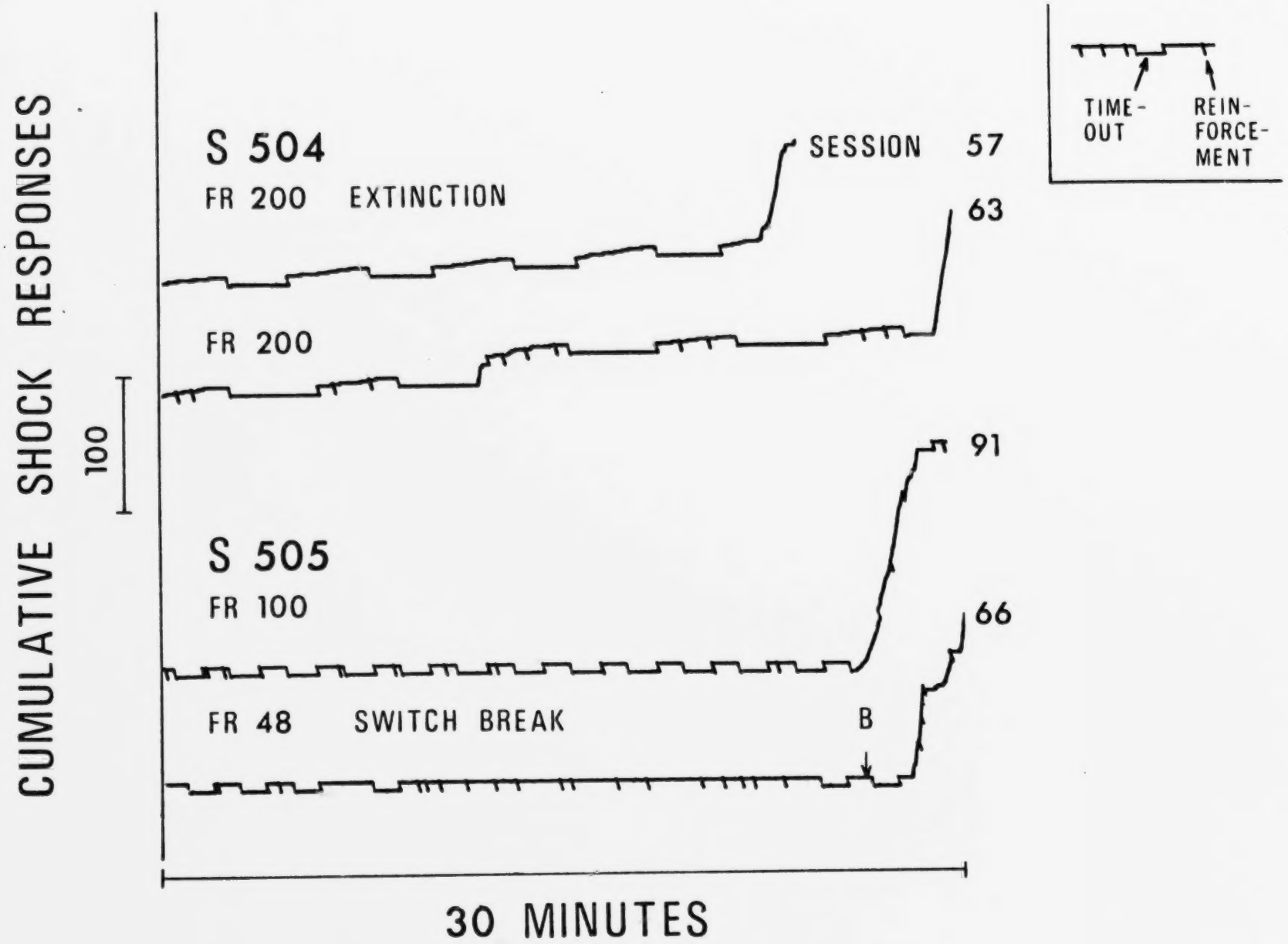

Figure 15

Sample cumulative records illustrating within-session acceleration in shock responding for S 504 and S 505. In the bottom portion of the figure, S 505's shock responding during session 66, during which the avoidance switch broke, is compared to responding under a too-high avoidance criterion (FR-100) in session 91. Arrow (B) indicates the point at which the avoidance switch broke. In the upper portion of the figure, shock responding on switch (A) for S 504 during session 57 was subjected to extinction, and is compared with responding under regular FR-200 avoidance contingencies.

The fact that this subject did not receive any money during session 57 appeared in no way to affect his shock rate in addition to the increment that might have occurred as a function of nonavoidance, in spite of extinction, as predicted from his responding in session 63. It could not be tested whether after prolonged exposure to extinction S 504 would have developed the same change in rate and pattern of shock responding as previously observed for S 507.

S 505 displayed a delayed reaction to the breakdown of the avoidance switch as demonstrated by the bottom cumulative record in Figure 15. The temporal occurrence of the breakdown is designated by an arrow in Figure 15. A rapid flury of 120 responses on the shock switch did not occur until the onset of the next warning period when the subject was unable to operate the avoidance switch. Cumulative effects were indicated by the fact that the behavior of delivering shock to the rat was sustained throughout the duration of the two subsequent time-out and reinforcement periods.

In this sense, the development of accelerated shock responding toward the end of the session is analogous to session 91 in which a high frequency of shock responses was emitted in reaction to continuous nonavoidance at a criterion too high for avoidance.

When after 12 subsequent sessions of regular FR-48 avoidance, the avoidance malfunction was systematically replicated, observed effects were not as dramatic as in the first instance. With an average of 3 shock responses during malfunction sessions as opposed to zero shock responses during two sessions before and after the malfunction procedure, the increment in rate of shocking the rat was

slight but systematic. All shock responses occurred immediately after the breadkown of the manipulandum.

The results obtained with these three subjects in this experiment suggest that there are at least two distinct elements of the avoidance of time-out schedule that represent potential antecedents for the behavior of delivering shock to a rat. These two factors are: First, interference with the obtainment of positive reinforcement and, second, interference with avoidance of an aversive event. For S 507, it was the first factor that proved to be relevant in provoking shock responses. No objective interference with meeting the avoidance had been introduced. Deterioration of the behavior under conditions of extinction was due to the fact that, by withholding positive reinforcement, the negative reinforcement contingency upon which avoidance behavior was based was also eliminated. Time-out was no longer a specific aversive event that had to be avoided. Thus, since there was no interference with avoidance behavior, immediate acceleration in shock responding during extinction appears to be functionally related to the absence of positive reinforcement.

The cause of the increment in shock responses of S 505 after malfunction of the avoidance switch is less clear. A close analysis leads to the conclusion that in his case interference with obtainment of positive reinforcement is ruled out as the major factor. The cumulative record of session 66 in Figure 15 shows no responses during the time-out period immediately after the switch breakdown, where shock responses would be expected if the malfunction were to

be understood as primarily a limitation on the amount of potential positive reinforcement. However, it is not until the onset of the next warning period which served as conditioned stimulus, signalling there the necessity of avoidance responding, that a burst of shock responses occurred. In other words, shock responses occurred when on the next opportunity for avoidance the subject found himself technically unable to initiate the required responses.

Similarly, S 504's behavior appeared to indicate that interference with avoidance behavior was the critical factor in evoking shock responses. There was no observable difference in the rate of shocking the rat between the extinction session (session 57) and the regular reinforcement session (session 63). Both sessions had a 0.0 avoidance probability; however, it was expected that because of the 0.0 probability of positive reinforcement in session 57, as opposed to a 0.5 probability in session 63, shock responding would be more frequent in the former session if it was, indeed, controlled by the amount of available reinforcement.

GENERAL DISCUSSION

The results of the present series of experiments showed that time-out from positive reinforcement will not only function as a negative reinforcer for the conditioning and maintenance of discriminated avoidance behavior in humans, but also elicit aggressive behave under certain conditions within the avoidance paradigm. These findings are consistent with several studies which give evidence that time-out from positive reinforcement exerts negative control over behavior in a number of different capacities. Investigations of time-out as an aversive event range from studies of continuous avoidance in humans (Baron and Kaufman, 1966; Baer, 1962a), monkeys and pigeons (Morse and Herrnstein, 1956; Ferster, 1958; Thomas, 1964) to studies of escape from time-out (Adelman and Maatsch, 1956) and escape from conditioned aversive stimuli that had been associated with the withholding of reinforcement (Wagner, 1963). The use of time-out from reinforcement as a punishment for behavior that is maintained by the same reinforcement was reported by Ferster (1958, Exp. V), Ferster and Appel (1961), and Holz, Azrin and Ayllon (1963); time-out as a punisher for undesirable behavior has been employed by Baer (1962b) and Bostow and Bailey (1969).

These studies suggest a parallel between time-out and other stimuli that produce avoidance and escape behavior and are thus classified as aversive. Keller and Schoenfeld (1950) empirically defined an event as aversive if it would produce an acceleration in

any behavior that serves to terminate or postpone it. A negative approach toward a definition was given by Mower (1960) and Kimble (1961), who contended that behavior which produced the aversive event would decrease in frequency below its operant level.

The studies cited present no exhaustive discussion of the functional properties of time-out from positive reinforcement. In other studies, relative aversiveness from time-out had been shown to be determined by its close dependency on the prevailing reinforcement baseline. Changes from a lower to a higher reinforcement density baseline (VI-9 to VI-1) resulted in a decrement in avoidance of time-out responding (Thomas, 1964).

Existence of a functional relationship between reinforcement availability and relative aversiveness of time-out is also reported by Holz, Azrin and Ayllon (1963). A response that was intermittently punished by time-out from the reinforcement by which it was maintained was eliminated only if an alternative response continued to provide reinforcement.

By definition, time-out from positive reinforcement derives its functional qualities from its association with the absence of reinforcement or reinforcement-related events. Since time-out is a conditioned and not a primary stimulus, its relative strength fluctuates with the nature of the schedule upon which it is superimposed. This basic operational connection with reinforcement suggests two alternative theoretical analyses of the type of control it exerts in negative reinforcement procedures, e.g., avoidance paradigms. For example, avoidance of time-out in the present studies, may have been

conditioned (1) because it was reinforced by an increase in reinforcement probability, or (2) because time-out was a strong conditioned aversive stimulus that could be postponed by making the required response (Leitenberg, 1965). In this respect, the discussion falls within the theoretical disputes about the process of avoidance learning: is avoidance behavior reinforced simply by objective reduction in density or frequency of aversive stimulation (Anger, 1956; Herrnstein, 1961, 1969; Herrnstein and Hineline, 1966) or by the termination of a conditioned aversive stimulus as implicit in the two-factor theories of avoidance (Hull, 1943; Miller, 1951; Mower, 1960).

The present study partially contributes to answering the question, whether time-out from positive reinforcement can be considered an aversive event. It has been shown that some aversive stimuli will elicit aggressive behavior (Ulrich and Azrin, 1962; Azrin, Hake and Hutchinson, 1956; Azrin, Hutchinson and Hake, 1966). Assuming that the response of shocking the rat as used in this study can be considered an aggressive response, the results showed a direct correlation between low reinforcement frequency and aggressive behavior. Sessions with a high frequency of time-out were characterized by an increase in shock responding compared to the level observed during avoidance session. Since aggressive behavior is a response to aversive stimulation, it can be concluded that avoidance responses were not primarily conditioned because they served to increase the frequency of potential reinforcement, but were established as a behavior that would postpone an aversive stimulus,

namely, time-out.

Aversiveness of time-out was directly determined by the potential reduction in reinforcement frequency. The decrement in avoidance responding evident during extinction can be seen as due to the fact that time-out associated stimuli no longer were uniquely connected to nondelivery of reinforcement. Consequently, their conditioned aversive properties were subjected to extinction.

The results of Experiments II and V demonstrated large differences in effect of low avoidance probabilities and extinction on rate of aggressive responses. Extinction produced a progressive acceleration in aggression that by far exceeded the rates of shock behavior induced by low avoidance probabilities. These differences could be accounted for by several factors: (1) During extinction, probability of reinforcement was zero, while during nonavoidance reinforcement probability was only reduced to .5, (2) Although the number of responses necessary for positive and negative reinforcement (avoidance) can be equated, there are more instances of frustration of responding on the reinforcement switch than on the avoidance switch. (3) Because of the higher frequency of frustration, the general energizing effect of extinction is more extensive (Amsel, 1958, 1962; Notterman, 1959; Birch, 1961), and thus possibly more likely to generalize to all responses available in the situation (Miller, 1948). (4) Withholding of reinforcement appeared to be a more arbitrary frustration than nonavoidance. Verbal comments of the subjects suggested that the latter was regarded as justified contingency for their failure to meet the requirement. Thus, it

appeared that a decrement in reinforcement frequency which was arbitrary, because it was not under the control of the subject, produced higher rates of aggressive behavior than contingent reduction in reinforcement (Pastore, 1952).

The results which indicate a correlation between aggressive responses and low probabilities of reinforcement are consistent with the findings of Azrin, Hutchinson and Hake (1966). They reported that transitions from food reinforcement to extinction would produce aggression in pigeons toward another pigeon whether or not the extinction period was signaled. Observed rates of attack were higher under an alternating reinforcement-extinction procedure than during no-reinforcement phases. Hutchinson, Azrin and Hunt (1968) and Gentry (1968) found high frequencies of attack behavior during post-reinforcement pauses or initial stages of the ratio run on high fixed-ratio schedules. Findings were interpreted as aggression-induced by elements of a reinforcement schedule that possessed aversive properties because of their association with low reinforcement probabilities.

Since low reinforcement probabilities and number of non-reinforced avoidance trials are synonymous in the present study, the findings can be expressed in terms of an inverse functional relationship between aggressive responses and avoidance probability. In this sense, results are analogous to findings by Azrin, Hutchinson and Hake (1967) who reported that during shock escape training, probability of attack and probability of escape were inversely proportionate. Initially, attack predominated the escape response, but as the

response became conditioned, attack progressively decreased in frequency until finally it was almost entirely displaced by the escape response. Ulrich and Craine (1967) found that shock-induced attack behavior between rats would interfere with the learning of an avoidance response. These data appear to suggest that as long as the operant response was ineffective in escaping or avoiding the aversive stimulus, aggressive behavior was dominant. The acceleration in rate of delivering shock to the rat during avoidance conditioning of Experiment I does not appear to be the same phenomenon. Since the subjects had no information about the function of the three manipulanda, responses on the shock switch appeared to be a behavior intended to investigate the reinforcement contingencies rather than a function of time-out frequency.

In a further study, Azrin, Hutchinson and Hake (1967), Ulrich, Stachnik, Brierton and Mabry (1965) and Ulrich (1967) found that under certain conditions, aggressive behavior would be dominant despite the availability of the avoidance or escape response. Wolfe (1967) emphasized the significance of the criterion for escape in determining whether the operant response would eventually displace the aggressive behavior. His data suggest that with higher criterion requirements, aggressive responses tend to disrupt ongoing operant behavior. These data are consistent with findings of the present study. At extremely high fixed-ratio requirements, the behavior of delivering shock to the rat did, indeed, dominate, if not displace, the avoidance behavior. The disproportionately large increase in avoidance IRTs, as shown for extreme ratios in Experiment I

(See Figure 3), reflects this phenomenon.

This distribution of shock responses during nonavoidance sessions differed significantly from the distribution obtained during avoidance sessions (See Figure 7). For all subjects, shock responding during the warning stimulus had increased by between 10 and 60 percent as compared to avoidance sessions. It appeared that the warning stimulus had become a conditioned aversive stimulus through its association with a too-high fixed-ratio avoidance criterion. Azrin (1961), Thompson (1964, 1965) reported that high fixed-ratio schedules of positive reinforcement have aversive properties from which a subject will escape if given the opportunity. Hutchinson, Azrin and Hunt (1968) showed that the same aversive portions of a high ratio will elicit aggressive behavior in pigeons and monkeys. This observation however, cannot be stated as a general conclusion with respect to aggression-inducing variables in the present experiments. When avoidance probability was 1.0, despite a high ratio up to FR-185, only a few shock responses occurred during the warning stimulus.

The functional relationship between avoidance probability and aggressive responses in the present study was not monotonic and not reliable from session to session. Frequently, avoidance probabilities less than 1.0 would not produce higher rates of shock delivery. Even sessions of total nonavoidance did not consistently result in increased shock responding. More typical was a behavior that demonstrated eventual cumulative effects of the variables under concern, as demonstrated in Figures 14 and 15 for between and within session effects. Inconsistencies included occasional rates of shock responding that deviated

drastically from the usual rates. Through casual conversation with the subjects, these deviations could sometimes be identified as the result of extraneous variables (e.g. flunking a test) that were not under the control of the experiment. Sessions like these uncover the problems of any experimental analysis of a complex human behavior such as aggression.

A large portion of the difficulties in analyzing aggressive behavior in animals and humans alike is represented by the response measure. If any analysis of the interaction between aggressive behavior and certain variables shall be valid, the response sensor must be reliable, valid and objective. Hutchinson, Azrin and Hake (1966) developed an automatic method for the investigation of aggression in squirrel monkeys that fulfilled the above requirements.

Studies of aggression in humans are less advanced in technical aspects. Paper-and-pencil tests have been used excessively in assessing aggressive tendencies (Buss Hostility Scale, Siegel Manifest Hostility Scale, Rorschach, TAT). Degree of autonomic arousal has been used as one operationally defined index of aggression (Hokanson and Burgess, 1962; Hokanson and Shetler, 1961). Other studies investigated frequency and intensity of a hitting response (Cowan and Walters, 1963), intensity of delivering fictious electric shock to a target subject (Milgram, 1963), and frequency of blocking or interrupting the performance of an instrumental task (Deutsch and Kraus, 1960; Ulrich and Favell, 1968).

The present series of experiments represented an attempt to make use of a methodology that allowed for an objective quantifi-

cation of aggressive behavior in humans. The results of this study can be understood only with the limitation that is implicit in the degree to which the response measure, i.e., delivering electric shock to a rat, is a reliable indicator of aggression in the subjects used in this study.

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FOOTNOTES

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[2]Now at the University of Oxford, Oxford, England.